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GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA.
ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

ON AN EXPLORATION

IN THE

YUKON AND MACKENZIE BASINS, N.W.T.

BY

R. G. McCONNELL, B.A.



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NOTE.—The bearings throughout this report are given with reference to the true meridian.

The invertebrate fossils have been determined by Mr. J. F. Whiteaves (for description of new species see Contributions to Canadian Palaeontology, vol. 1, part iii), the fossil plants by Sir William Dawson, and the recent plants by Professor Macoun.

The name Pelly-Yukon, as a compromise between the old name and the new, is used in [this] report to designate the continuation of the Yukon River above Fort Yukon to the junction of the Lewes and Pelly.

A. R. C. SELWYN, C.M.G., LL.D., F.R.S.,

Deputy Head and Director Geological Survey Department.

SIR,—I beg to present herewith a report on an exploration in the Mackenzie and Yukon country, carried out during the seasons of 1887-88, in connection with the Yukon exploring expedition. Only one season's work was at first contemplated, and no provision was made before starting for wintering in the north and continuing the work for a second summer, and for the means of doing so I am indebted to the kindness of the Hudson's Bay Company. Mr. Camsell, Chief Factor of the Mackenzie River District, afforded me every assistance in his power, and my thanks are also due to Mr. Reid, of Fort Providence, with whom I passed the winter; to Mr. Hodgson, of Fort Macpherson, and to all the officers of the company with whom I came in contact. I have also to thank the Rt. Rev. Bishop Bompas, the Ven. Archdeacon McDonald and the Rev. Mr. Canahan, of the Church Missionary Society, for ready assistance and advice.

It may be mentioned here that the late date at which this report is issued is due to a delay in the drafting of the accompanying index and route maps, caused by the pressure of other work.

I have the honor to be,

Sir,

Your obedient servant,

R. G. McCONNELL.

GEOLOGICAL SURVEY OFFICE, May 9th, 1891.

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INTRODUCTION AND SUMMARY OF PROCEEDINGS.

The work on which the following report is based, was carried out under the direction of Dr. G. M. Dawson in connection with the Yukon Exploring Expedition,* and occupied parts of the seasons of 1887-88. I separated from the main party on the 25th June, 1887, at the junction of the Dease and Liard Rivers, with instructions to descend the Liard and make a geological examination of the valley, and with discretionary orders, when this was accomplished, either to winter in the country and continue the exploration the following summer, or to make my way out by Slave River and the Athabasca and return to Ottawa the same season. Both of these plans proved feasible, but as I was able to make satisfactory arrangements with the Hudson's Bay Company to stay at Fort Providence, one of their posts on the Mackenzie, I decided to adopt the first mentioned.

I arrived at Fort Simpson on the 5th of August, and as there was still time to carry on considerable work before the setting in of winter, I took passage on board the Hudson Bay Company's steamer *Wrigley* for Fort Smith, on Slave River, and embarking there in a bark canoe with a couple of Indians the remainder of the season was spent on Slave River, Salt River, and Hay River, and in coasting around part of the western end of Great Slave Lake. About the 1st of October I returned to Fort Providence and went into winter quarters.

* Annual Report Geological Survey of Canada, Vol. iii.

Work during winter.

Exploratory work was necessarily suspended during the greater part of the winter, but rough traverses were made at intervals to Lake Bis-tshô, Fort Rae, and other places in the vicinity of Fort Providence, and while staying at the post meteorological observations were recorded twice a day.

Leave Fort Providence.

I left Fort Providence on the 1st of May, 1888, travelling on the ice with dogs, and reached Fort Simpson, at the mouth of the Liard, on the 6th, where I remained until the river became sufficiently free from ice to allow travelling by boat. The river broke up on the 13th of May, but continued full of floating drift ice all the month. On the 28th of May, having had a boat built at Fort Simpson in the meantime, I left that post, accompanied by two Indians and spent about a month descending and examining the valley of the Mackenzie as far as the mouth of the Peel, and in ascending the latter river to Fort McPherson. Here a delay of a few days, caused by the non-arrival at the expected time of the Mackenzie River boat, on which I depended for some supplies, enabled me to make a short exploratory trip up Rat River to the mountains.

Trip up Rat River.

On the 12th of July, the Mackenzie boat not having then arrived, and it being uncertain how much longer it would be delayed, I decided to risk obtaining supplies at Rampart House on the Porcupine, rather than waste any more of the short summer season, and started across the Rocky Mountains by what is called the Peel River Portage. Lapierre House, on the western side of the mountains, was reached on the 15th, and having meanwhile had my boat taken across the mountains by some Indians (who followed a route to the north of mine), I immediately started down the Porcupine, accompanied by an ex-employé of the Hudson's Bay Company named Skee, whom I engaged to go to the coast with me and who proved to be a capable voyageur. We made the descent of the Porcupine in safety and reached the site of old Fort Yukon, at the mouth, on the 24th.

Descend the Porcupine.

From this point the coast and outside communication can be reached either by descending the Yukon to St. Michael's, or ascending it to the head of the Lewes, about 850 miles, and crossing the Coast Range by the Chilkoot Pass. The former is by far the easier route, as the lower part of the Yukon presents no obstacle to navigation, but as it lay altogether beyond Canadian territory it was decided, if possible, to try and ascend the stream. A second boatman, in the person of a Loucheux Indian, was engaged. No boat was available except the one in which we had descended the Porcupine and which was thoroughly unsuitable for up-stream navigation, but in this, by the greatest exertion, we managed to breast slowly the impetuous current of the river and arrived at Forty Mile Creek after a laborious trip of fifteen days. At

this place, which is the headquarters of the miners on the Yukon, a ^{Ascend the} suitable boat was built and the ascent of the upper part of the river ^{Yukon,} was made with less difficulty. We left Forty Mile Creek on the 14th of August and arrived at Chilkoot Pass on the 15th of September, Juneau on the 21st, and Victoria on the 1st of October.

The total distance travelled from the time I left the coast at Fort Wrangell until I reached it again at the head of Lynn Canal was about ^{distanse travelled.} 4,000 miles, 3,000 miles by water and 1,000 on foot, and the time occupied in actual work was about seven months.

Among the more important geographical results of the exploration ^{Geographical results} may be mentioned the traverses of the Liard from Dease River to the Mackenzie, of the lower part of Hay River, of the Rocky Mountains by the Peel River Portage, and of Bell River and the Porcupine, from Lapierre House to Fort Yukon. A sketch traverse of the Mackenzie, from Fort Simpson to the mouth of Peel River, was also made, but as this portion was afterwards measured with the micrometer by Mr. Ogilvie, I have adopted his survey in the accompanying map, but have used my own notes to sketch in the topography of the adjoining country. Another result of the exploration of some interest to the geographer is the discovery of a great break in the continuity of the Rocky Mountains in about lat. 60° N. The range here is suddenly jogged eastward for a couple of degrees and is then continued northward along nearly the same bearing as before.

The geological examination of the routes traversed was necessarily ^{Character of work.} conducted in a somewhat hasty manner and can make little pretension to completeness. Detailed observations are obviously out of the reach of a traveller hurrying along at the rate of twenty to thirty miles a day through a country more or less complicated, and especially when in addition to the ordinary surveying and geological work the duties of pilot and head boatman also fall to his share. Fortunately, in the present case, the effects of haste were compensated to some extent by a familiarity with most of the terranes met with, acquired by several years experience among similar rocks to the south. Also, at the more important points and at the contacts of the different formations short halts were called and more extended examinations made. In this manner it proved possible to obtain at least a general knowledge of the geology of the routes traversed, and to outline approximately the limits of the greater geological divisions.

Such notes as were collected on the fauna and flora of the country travelled through, and which seem worthy of publication, are, in order to avoid repetition, incorporated in the general description, along with the topographical and geological details. This course,

though leading to some confusion, can hardly be avoided in an account of a hasty general exploration, such as the one treated of. The meteorological notes are given in the form of an appendix at the end.

PRINCIPAL PHYSICAL FEATURES.

Extent of region.

The region travelled through and partially examined embraces the extreme north-western portion of the Dominion of Canada, and has a length from north to south of 650 miles, a width from east to west of 350 miles, and an approximate superficial area of 227,000 square miles. The whole of this great district lies on the arctic slope of the continent, and is included in the drainage basins of the Mackenzie and the Yukon. It is traversed, in a direction a little north of west, throughout its whole length by the Rocky Mountain chain, which constitutes the main water parting of the district.

Rocky Mountains

The Rocky Mountains enter the district on the south between long. 126° W. and $126^{\circ} 30'$ W., as an assemblage of nearly parallel limestone ridges, striking in a north-westerly direction, and rising to altitudes of 3,000 to 4,000 feet, but diminish rapidly both in height and width before reaching the Liard, in lat. $59^{\circ} 30'$ N., and appear to die away in this latitude shortly after crossing this stream. Two degrees farther east ranges of limestone mountains rise suddenly from the plains up to heights of 3,000 to 4,000 feet, and, striking in a northerly direction, extend without any interruption, so far as known, to lat. $67^{\circ} 30'$ N. and beyond.

South-western part of district.

In the south-western part of the district, the country lying between the Cassiar Mountains and the Rocky Mountains, and drained by the Liard and its tributaries, may be described as an irregular, forested plain, relieved at intervals by short disconnected ranges of rounded hills, which appear to become more numerous as the Rocky Mountains are approached. Its surface irregularities and rounded lines of relief are evidently the result of long-continued denudation. This plain slopes gently to the south-east, and has an average elevation of about 2,000 feet above the sea, while the hills and ridges resting on it rise 1,000 to 1,500 feet higher. The northern extension of the plain is unknown. To the south it is closed by ranges of mountains.

Foot-hills.

In the south-eastern part of the district the Rocky Mountains are bordered by a foot-hill belt about thirty miles wide, which is characterized, here as elsewhere, by long, nearly parallel ridges, often crested with tilted sandstone beds, but also contains some high peaks little inferior in elevation to those of the central range. Of these Mount Prudence, which is situated a few miles south of the Devil's Portage

on the Liard, forms the most conspicuous example, and was estimated to have a height of nearly 4,000 feet above the river. The foot-hill belt is fringed in the latitude of the Liard by a high plateau built of flat-lying Cretaceous beds, through which the river has cut a great gorge, which in some places is fully 1,000 feet deep. The surface of this plateau has been carved by the drainage system into a series of irregular flat-topped elevations.

East of the fringe of high plateaus the plains in the neighborhood of the Liard slope uniformly eastwards towards the Mackenzie, while farther to the south-east, along the Lake Bis-tehō trail, they descend to the same level by a series of steps and escarpments. East of the Mackenzie a flat plain stretches eastwards for thirty miles to the base of a steep escarpment called the Horn Mountains. This was not examined, but is reported to be merely the westerly face of a higher plateau running parallel with the Mackenzie. It corresponds in a general way to those west of the river, but faces in the opposite direction. The whole of the country bordering the Mackenzie in this latitude, on both the lower and higher levels, so far as examined, is thickly mantled with drift. The surface is usually more or less undulating, and is diversified by innumerable shallow lakes of all sizes, while a large proportion is underlaid by muskegs and marshes, covered with sphagnum or bog-moss, which remain frozen throughout the year. The higher lands and ridges separating the lakes and marshes are usually rather densely forested, chiefly with white spruce (*Picea alba*), the Banksian pine (*Pinus Banksiana*) and the aspen (*Populus tremuloides*).

The eastern part of the district examined is traversed throughout by the Mackenzie. This great stream is described in some detail in a subsequent part of this report, and need only be referred to here. It ranks among the first dozen rivers of the world, and in length and size of basin is, on the North American continent, second only to the Mississippi. The volume of water carried by the Mackenzie is not known exactly, but such rough measurements and estimates as I was able to make showed it to have, at a medium stage, an approximate discharge of the water, of 500,000 square feet per second. It issues from Great Slave Lake with a width of several miles, but soon contracts to about a mile, and then maintains this as an average width all the way to the sea, the host of streams which enter it at various parts of its course being apparently incapable of increasing its size to any appreciable extent. The current of the Mackenzie at a high or medium state of the water is remarkably uniform throughout its whole length, but in low water its course is interrupted by several small rapids. It has an average fall of about six inches to the mile.

Tributaries.

The principal tributaries of the Mackenzie, north of Great Slave Lake, are the Liard, which originates west of the Rocky Mountains, and breaks through that range on its way to join the parent stream, Bear River, the outlet of Great Bear Lake, and Peel River, which drains the eastern slopes of the northern portion of the Rocky Mountains.

Plains bordering the Mackenzie.

The plains bordering the Mackenzie above the Liard have already been referred to. Below the mouth of the Liard the Mackenzie rapidly approaches the Rocky Mountains, and in lat. $62^{\circ} 15'$ N. impinges against them and is then deflected more to the north parallel to their course. Thirty miles farther down a high ridge appears on the eastern bank of the river, and this, followed for a short distance, soon develops into a high mountain range crested with bare limestone peaks and ridges exactly similar to those flanking the valley on the west. This point may be considered as the northern limit of the great central plain of the continent. The mountains here rise suddenly from the plains to heights of 3,000 to 4,000 feet, without any fringing belts of foothills and plateaus such as accompany them elsewhere.

North of the point at which the Mackenzie enters the mountains it is flanked on both sides by lofty and almost continuous ranges of limestone mountains to near the Sans Sault Rapid, in lat. $65^{\circ} 40'$ N. The lowlands between the two ranges through which the river flows have a width of from twenty to sixty miles. They are broken by low plateaus and by a number of short ranges such as Bear Rock, Roche Carcajou, and the Rock by the River Side, but contain no elevations exceeding 2,000 feet in height.

Mountains disappear.

North of lat. $63^{\circ} 40'$ N. the ranges east of the Mackenzie lose their importance and gradually disappear, while those on the western side recede beyond the range of vision, and the river flows through a dreary plain, covered to a large extent by lakes and frozen marshes, which extends northwards to the Arctic Coast. The coniferous forest, varied in places by aspen-covered tracts, still continues, but the trees present a stunted appearance, and except in sheltered localities seldom exceed six to eight inches in diameter. Isolated groves and individual trees were, however, noticed even far within the Arctic circle, which equal in size those found in the upper reaches of the river.

Mountains at Peel River Portage.

North of lat. 67° N. the Mackenzie bends suddenly westward and at the mouth of Peel River again approaches the Rocky Mountains, but the range here presents few familiar features. It may be described, where crossed in lat. $67^{\circ} 20$ N., as a huge ridge, sixty miles wide and 2,500 feet high, surmounted by two longitudinal ranges of mountains rising to heights of from 1,000 to 2,500 feet above the sum-

mit of the ridge. The forests extend only a short distance up the slopes and the greater part of the surface is either bare or covered with mosses and coarse grasses.

West of the Rocky Mountains in the north-western part of the district, a rugged mountainous region, clothed on the lower levels with a monotonous coniferous forest, stretches westwards to the Alaskan boundary. This region is drained into the Yukon by the Porcupine and its tributaries, and has an elevation above the sea of from 1,000 to 1,500 ft. It contains numerous short ranges of mountains and hills, but these appear to be entirely independent of one another, and trend in different directions.

Country west
of mountains.

The tract of country in the western part of the district lying between the Pelly-Yukon and the Rocky Mountains, south of the Porcupine, is almost unknown. It is drained principally by the Stewart and its tributaries, and is reported to be hilly and mountainous throughout. One range of high limestone mountains skirts the Pelly-Yukon on the east some distance above the boundary striking a little east of south, while a second range, according to the miners, follows up the north bank of the Stewart. On most maps a range of mountains is shown crossing the Pelly-Yukon below the mouth of the Stewart and continuing on into Alaska. The country bordering the river here is higher than usual as shown by the increased depth of the valley, but no definite range was noticed.

NAVIGABLE WATERS.

The Mackenzie River and its continuation Slave River are navigable from Fort Smith at the foot of the Slave River rapids to the Arctic ocean, a distance of over 1,300 miles. A small steamer built by the Hudson's Bay Company at Fort Smith, in the winter of 1886-8, now makes annual trips from that post down Slave River and the Mackenzie as far as the mouth of Peel River, which enters the latter at the head of its delta, and thence thirty miles up Peel River to Fort Macpherson. The navigable season for the whole route barely averages three months as Great Slave Lake is seldom free from ice much before the 1st of July, and in September the rapids at the head of the Ramparts become impassable, while at low water the wide channel at the outlet of Great Slave Lake does not exceed four to six feet in depth. Long stretches of the river are, however, navigable for nearly five months.

Navigable
of the Mackenzie.

An account of the breaking up of the ice on the Mackenzie and Liard is given in another place (see page 87 D). The Liard opens at Fort Liard about the 25th April, and is usually clear as far as its

mouth before the 10th May. The impact of the moving Liard ice breaks up the sheet covering the Mackenzie, and clears in the course of a month a passage to the sea. Above the mouth of the Liard the ice on the Mackenzie usually remains firm until near the 20th of May. On Great Slave Lake the opening of navigation varies from the 18th June to the 5th July.

In the autumn of 1887 drift ice was floating past Fort Providence on the 21st of October, and on the 16th of November the river was frozen across. Great Slave Lake is usually frozen for some distance from the shores before the end of October.

It follows from these dates that the Mackenzie, disregarding the obstructions in low water from rapids, cannot be considered as navigable much before the 10th of June nor later than the 20th of October. On Great Slave Lake the navigable season lasts from about the 1st of July to the end of October.

*Navigatio*n of
the Liard.

The navigation of the Liard, the principal tributary of the Mackenzie, is interrupted about twenty miles above its mouth by a series of strong riffles. These might possibly be overcome by the use of the line, but the steamer *Wrigley* has not yet attempted to stem them. Above the riffles the Liard is easily navigable as far as Fort Liard and thence on up the west branch as far as Hell Gate. Above Hell Gate its navigation, owing to the numerous rapids and cañons, is exceedingly difficult and dangerous even with small boats. The Nelson or East Branch of the Liard is reported to be navigable by small steamers for a hundred miles or more above its mouth.

Of the other tributaries of the Mackenzie, Peel River is the only one which can be considered as navigable. This is ascended annually as stated above by the steamer *Wrigley* as far as Fort Macpherson, a distance of about thirty miles, and if necessary could be followed much farther, but the exact distance is not known.

*Navigatio*n of
Rat River and
the Porcupine.

On the west side of the Rocky Mountains, Rat River and the Porcupine could easily be navigated for three or four months of the year, by small steamers, from Lapierre House down to the junction of the latter with the Yukon. Above the mouth of the Porcupine the Yukon, beyond a stiff current of from four to five miles an hour, presents no obstacle to navigation as far as Rink Rapids, a distance of over five hundred miles, and below the mouth of the Porcupine it is navigable to the sea. Stewart River, the principal tributary of the Yukon on the east in the district examined, is reported to be navigable for a distance of nearly two hundred miles above its mouth, but has not yet been ascended by the steamers plying on the Yukon.

The navigable waters of the Mackenzie are separated from those on

the Yukon in lat. $67^{\circ} 20' N.$ by a distance of about sixty miles only. A cart trail was staked out some years ago by the Hudson's Bay Company across the interval separating these rivers with the intention of supplying the Mackenzie River district with goods by way of the Yukon, but the project fell through and the road was never built.

GEOLOGICAL SUMMARY.

CRYSTALLINE SCHISTS.

The region examined lies to the west of the great Archean axis of the continent, and the rocks of this system were only seen at two points ^{Archean rocks.} east of the Rocky Mountains. At the foot of the rapids on Slave River they consist of coarse grained granitoid gneisses indistinctly foliated, and at Fort Rae of a medium grained biotite granite-gneiss. At both these places the gneisses evidently belong to the Laurentian, or oldest division of the Archean.

In the Rocky Mountains themselves no pre-Cambrian rocks were observed.

West of the Rocky Mountains crystalline schists are largely developed along the valley of the Pelly-Yukon. They were first met with, in ascending the river, near the International Boundary, and were then traced southwards by numerous exposures as far as Fort Selkirk, at the junction of the Lewes and Pelly, and they continue on up the Lewes about thirty miles farther. The belt of crystalline rocks has a width of something over a hundred miles and strikes in a south-easterly direction from the International Boundary, or lon. $141^{\circ} W.$ diagonally across the Pelly-Yukon and up the Pelly to near its head, and then continues on across the Frances River.* The extension of the belt beyond the Frances River is not known. It does not reach the Liard, however, as no crystalline schists were noticed on that stream. South of the latitude of the Liard the crystalline rocks, like the Rocky Mountains themselves, do not continue southwards along their old strikes, but along parallel strikes a couple of degrees farther west. The break in the continuity of the Rocky Mountains, which is referred to on another page, has its counterpart in a break in the continuity of the belt of crystalline rocks which usually accompanies them on the west.

The dips of the crystalline rocks along the Pelly-Yukon are usually ^{Dip of rocks.} westerly and at high angles.

Along the eastern edge of the crystalline belt the rocks are characterized by a general greenish colour and consist largely of altered volcanic <sup>Character of
crystalline
rocks.</sup>

* Annual Report Geol. Survey, 1887-88, part B.

rocks. The most important variety is a sheared and altered greenish quartzose schist. With this are associated greenish chlorite bearing schists, lustrous mica-schists, diabases and serpentines. The schists are interbedded with occasional bands of slates and crystalline limestones, and are broken through in many places by igneous intrusions.

The green schists are underlain in ascending the river by a great thickness of well foliated mica-gneisses alternating with mica and hornblende schists, which are distinctly Archean in appearance and lithological characters. They bear a strong general resemblance to the Archean rocks, recently described by Dr. Dawson from the western part of the Selkirks. Granite intrusions occur in the gneissic area, but less frequently than in the green schist belt.—(See pp. 143, 144).

CAMBRO-SILURIAN.

Cambro-Silurian rocks.

The greater part of the unfossiliferous dolomites, limestones and cale-schists found along the Liard, west of the Rocky Mountains, are identical in lithological characters with the Castle Mountain group of the Bow River section, and are probably of Cambro-Silurian or later Cambrian age. Similar rocks also form the base of the geological section in the Nahanni Butte, and in the mountains near the bend of the Mackenzie, seventy miles below Fort Simpson. The Cambrian slates and quartzites which underlie the limestones and dolomites of the Castle Mountain group along the Bow River are not brought to the surface, so far as observed, in the mountains along the Liard and Mackenzie.

No rocks holding Silurian fossils were found in any part of the district.

DEVONIAN.

Distribution of the Devonian.

Devonian rocks were not definitely recognized west of the Rocky Mountains. East of the mountains they have a wide distribution and underlie the greater part of the country bordering the Mackenzie, all the way from Great Slave Lake to below old Fort Good Hope, a distance measured in a straight line of over 700 miles. They were found all around the western arm of Great Slave Lake and were traced up Hay River to the falls and up the Liard to the "Long Reach." South of the Liard and extending as far south as Peace River, the Devonian outcrops at the surface in a broad band, averaging fully 150 miles in width, striking in a north-westerly and south-easterly direction, parallel to the western margin of the Archean axis. On the

southwest it is generally overlain by the Cretaceous, and on the northeast overlaps all the older Palaeozoic formations and comes directly in contact with the Archaean. In all this region the beds are practically undisturbed and are seldom affected by dips exceeding a few feet to the mile.

North of the Liard the Devonian has become involved in the foldings of the Rocky Mountains, but in the plain followed by the river between the ranges, the beds, except in a few places, such as Rock Island opposite Fort Wrigley, Rock by the River Side, and Bear and Carcajou Mountains, are horizontal or nearly so, and rocks older than the Devonian are seldom brought to the surface.

For some miles above the mouth of Bear River the Devonian, which forms the top of the Palaeozoic system in the district, is overlain unconformably by the Cretaceous, and Cretaceous outliers of limited extent occur at intervals all the way to the Upper Ramparts. Below the Ramparts Devonian rocks are traceable by numerous exposures as far as old Fort Good Hope, where they disappear beneath the Cretaceous.

Throughout the Mackenzie district the Devonian is generally divisible lithologically into an upper and lower limestone, separated by a varying thickness of shales and shaly limestones, but in some cases limestones occur throughout. The upper division has an approximate thickness of 300 feet and consists of a compact yellowish weathering limestone occasionally almost wholly composed of corals, interstratified with some dolomitic beds. This limestone is well exposed at the falls on Hay River and also at the Ramparts on the Mackenzie. In both these places it is underlain by several hundred feet of greenish and bluish shales, alternating with thin limestone beds. At the "Grand View" on the Mackenzie the shales are hard and fissile, and are blackened and in places saturated with petroleum. At the Rock by the River Side, and at other places where the beds are tilted and older rocks exposed, the middle division is underlain by 2,000 feet or more of greyish limestones and dolomites interbedded occasionally with some quartzites. No fossils were collected from the lower part of this series, and rocks older than the Devonian may possibly be represented in it.

Representative collections of fossils, showing a mixture of Hamilton and Chemung forms, were obtained from the upper part of the shales on Hay River, at a point about forty miles above its mouth, and from the same horizon at the Ramparts on the Mackenzie. The lithological characters and the stratigraphical relations of the limestones at these two points, notwithstanding the fact that they are separated by a distance of over 570 miles, are almost identical. The

fossil faunas also, at the two points, show similar close relations, the principal differences being the presence of *Rhynchonella cuboides* and *Spirifera disjuncta* at Hay River, and of *Stringocephalus Burtini* at the Ramparts. This might seem to indicate that the beds at the Ramparts are slightly older than those at Hay River, but Mr. Whiteaves thinks that both are referable to the Cuboides Zone. A number of smaller collections of fossils were obtained at various points along the Mackenzie, and a complete list as determined or described by Mr. Whiteaves is given below.

SPONGIÆ.

Astracospongia Hamiltonensis, Meek and Worthen. Hay River.

ANTHOZOA.

Aulopora serpens, Schlotheim. Hay River.

ZOANTHARIA.

Streptelasma rectum, Hall. Mackenzie River, ten miles below Bear River.

Cyathophyllum arcticum, Meek. Rampart, Mackenzie River.

Cyathophyllum Richardsoni, Meek. Ramparts, Mackenzie River.

Campophyllum ellipticum. Hay River.

Campophyllum cespitosum, Goldfuss. Hay River.

Heliophyllum parvulum, Whiteaves. Hay River.

Phillipsastræa Hennahi, Lonsdale. Hay River.

Phillipsastræa Verrillii, Meek (Sp.). Hay River.

Cystiphyllum Americanum var. *arcticum*, Meek. Ramparts, Mackenzie River.

Pachypora cervicornis, DeBlainville. Hay River; and Ramparts Mackenzie River.

Alveolites vallorum, Meek. Hay River; and Ramparts, Mackenzie River.

CRINOIDEA.

Arachnocrinus Canadensis, Whiteaves. Hay River.

VERMES.

Spirorbis omphalodes, Goldfuss. Hay River; and Ramparts, Mackenzie River.

Spirorbis Arkonensis, Nicholson. Hay River.

POLYZOA.

Hedrella Canadensis, Nicholson. Hay River and Ramparts, Mackenzie River.

Proboscina laxa, Whiteaves. Hay River.

Stomatopora moniliformis, Whiteaves. Hay River.

Ascodictyon stellatum, Nicholson. Hay River.

Paleswhara quadrangularis, Nicholson (Sp.). Hay River; and Ramparts, Mackenzie River.

Ceramopora Huronensis, Nicholson. Hay River.

BRACHIOPODA.

Crania Hamiltonia, Hall. Hay River.

Productella subaculeata, var. *cataracta*, Hall and Whitfield. Rock by river side, Mackenzie River.

Productella spinulicosta, Hall. Hay River; and "Grand View," Mackenzie River.

Productella lachrymosa, var. *lima*, Hall. Ramparts, Mackenzie River.

Orthis striatula, Schlotheim. Hay River; and Ramparts, Mackenzie River.

Strophodonta demissa, Conrad. Hay River.

Spirifera disjuncta, Sowerby. Hay River.

Spirifera disjuncta var. *occidentalis*, Whiteaves. Hay River.

Spirifera cyrtinaformis, Hall and Whitfield. Hay River.

Spirifera (Martinia) glabra, var. *Franklini*, Meek. Hay River; and Ramparts, Mackenzie River.

Spirifera (M.) meristoides, Meek. Ramparts, Mackenzie River.

Cyrtina Hamiltonensis, Hall. Ramparts, Mackenzie River.

Atrypa reticularis, Linnaeus. Hay River; the Ramparts and "Grand View," Mackenzie River.

Atrypa reticularis, var. *aspera*. Hay River; the Ramparts, and "Grand View," Mackenzie River.

Rhynchonella pugnus, Martin. Ramparts, Mackenzie River.

Rhynchonella cuboides, Sowerby. Hay River.

Rhynchonella castanea, Meek. Ramparts, Mackenzie River.

Eatonia variabilis, Whiteaves. Hay River.

Pentamerus galeatus, Dalman. Ramparts, Mackenzie River.

Stringocephalus Burtini, Defrance. Ramparts, Mackenzie River.

Cryptonella Calvini, Hall and Whitfield. Ramparts, Mackenzie River.

Newberria (Rensselaeria) laevis, Meek (Sp.). Ramparts, Mackenzie River.

PELECYPODA.

Paracyclas elliptica, Hall. Ramparts, and ten miles below Bear River, Mackenzie River.

Schizodus Chemungensis, Conrad. Hay River.

GASTEROPODA.

Euomphalus (Straparollus) inops, Hall. Ramparts, Mackenzie River.

Euomphalus (Straparollus) flexistriatus, Whiteaves. Ramparts, Mackenzie River.

Euomphalus Maskusi, Whiteaves. Hay River.

CEPHALOPODA.

Orthoceras (two species). Hay River.

Goniatites. Hay River.

CRUSTACEA.

OSTRACODA.

Primitia scitula, Jones. Hay River.

Aparchites mitis, Jones. Hay River.

Isochilina bellula, Jones. Hay River.

TRILOBITA.

Proetus Haldemani, Hall. Ramparts, and Grand View, Mackenzie River.

The limestones which rise from beneath the Cretaceous on the Liard a few miles below Fort Liard hold fossils characteristic of transition beds between the Devonian and the Carboniferous. — The following species were collected there from one exposure :—

Streptorhynchus, like *S. umbraculum*.

Spirifera, two ribbed species.

Spirifera (Martinia) setigera, Hall.

Athyris subquadrata, Hall.

Proetus peroccidens, Hall and Whitfield.

Similar transition beds occur all along the Rocky Mountains, south to the International Boundary, but have not been detected heretofore east of the Cretaceous basin of the plains.

TRIAS.

Beds holding Triassic fossils occur along the Liard in the eastern foot-hills of the Rocky Mountains. They consist of dark shales, usually rather coarsely laminated, and passing into calcareous shales interstratified with sandstones and shaly and massive limestones. The latter are moderately crystalline, are dark in colour, and are usually very impure. They are harder than the shales, and at Hell Gate narrow the valley into a cañon. The beds undulate, usually in easy folds, along the valley, and are exposed in numerous disconnected sections, but it was found impossible in hurrying through to make even an approximate estimate of their thickness. Triassic fossils were found at the Rapids of the Drowned, at Hell Gate and at one intermediate point. It is probable, however, that a considerable proportion of the barren shales east and west of these points are also of Triassic age. All the fossils collected have been examined by Mr. Whiteaves, and the following list of species, nine of which are described by him in Vol. I, pt. 2, of the "Contributions to Canadian Palaeontology," is furnished by him:—

- Spiriferina borealis.*
- Terebratula Liardensis.*
- Monotis ovalis.*
- Halobia (Daonella) Lommelli*, Wissman.
- Halobia occidentalis.*
- Nutilus Liardensis.*
- Popanoceras Mc Connelli.*
- Trachyceras Canadense.*
- Trigonodus ? productus.*
- Margarita Triassica.*

Triassic beds were not detected along the eastern edge of the Liard Cretaceous basin. They are also absent from the valley of the Mackenzie, as the Cretaceous rocks were found there in a number of places resting directly on the Devonian.

CRETACEOUS.

Fossiliferous Cretaceous beds were not recognized in descending the Liard until the plateau belt which borders the eastern foot-hills was reached. Below Fort Halkett, west of the mountains, a band of soft dark shales crosses the river, which may be in part Cretaceous, but no fossils were found in it. The eastern foot-hills are built of a great series of alternating shales and sandstones, with some limestones, all folded closely together, which resemble those found in the foot-hills farther

Character and age of beds.

south, and, like them, probably consist largely of Cretaceous rocks, but it was found impossible on a hasty trip along one line to separate these from the Triassic, or from the shales which cap the Palaeozoic system, owing to the lithological similarity which prevails throughout. East of the foot-hills the convolutions gradually cease and the section becomes more legible. The beds here consist of soft, finely laminated shales, interstratified with a few beds of sandstone and ironstone. They have a minimum thickness of 1,500 feet. The shales yielded some fossils among which were several specimens of *Placenticeras Peruvianum*, one of the characteristic fossils of series C. of the Queen Charlotte Islands. With this were species of *Campitonectes* and *Inocerami*. Near the eastern edge of the plateau belt the shales are overlain by massive beds of rather soft sandstones and conglomerates, the thickness of which was not ascertained. The conglomerates are affected by a gentle easterly dip, and descend to the level of the river in the course of a few miles. From the point at which they disappear to the eastern edge of the Cretaceous basin, the rocks consist of dark fissile shales, crumbly sandy shales and sandstones, but the exposures along the valley are infrequent, and the succession soon becomes obscure.

Age of Cretaceous.

The Cretaceous section along the Liard thus shows two great shale and sandstone series separated by a heavy band of sandstones and conglomerates. The lower shales, from the imperfect fossil evidence at hand, and also from their lithological character, may be referred tentatively to the horizon of the Queen Charlotte Islands or Koontanie formation, the upper shales to that of the Benton, while the intervening conglomeritic band probably represents the Dakota. The lithological succession of the Cretaceous beds here is almost identical with that which obtains in other parts of the Cordilleran belt north of the International Boundary and on the Queen Charlotte Islands,² and shows that similar conditions of deposition prevailed at the same time over this whole area.

The Cretaceous rocks cross the Liard with a width of over a hundred miles, and north of the river enter a bay in the mountains, the extent of which to the north-westward is not known; southwards they are connected with the great Cretaceous basin of the plains.

Junction of Cretaceous with Devonian.

Fifteen miles below Fort Liard the Devonian limestones rise to the surface, but the junction between them and the overlying Meozoic rocks is concealed, and I was unable to ascertain whether the older beds continue to the eastern edge of the basin or are here overlapped by the Upper Cretaceous. It is probable, however, that the latter is the case.

² Am. Journ. Sci., Vol. XXXVIII, p. 120.

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The plains bordering the lower part of the Liard and the upper part of the Mackenzie rest on Devonian limestones and shales, and Cretaceous rocks were not detected in descending the latter stream until the Dahadinni River in lat. 64° N. was reached. They consist here of a couple of hundred feet of dark grey shales and sandstones. They are exposed along the valley for ten or twelve miles, and are then concealed by the boulder-clay, but probably continue under the latter as far as the Tertiary basin at the mouth of Bear River, a distance of fifty miles. The Cretaceous beds here occupy a depression between two high ranges of limestone mountains and cannot have a greater width than ten or fifteen miles. They have been separated from the Cretaceous beds which form the western shores of Great Bear Lake by the elevation of the Mount Clark range.

Forty miles below Bear River the Cretaceous beds reappear on the banks of the Mackenzie, and with the exception of one break of a couple of miles where they have been removed by denudation, underlie the valley all the way to the Ramparts, a distance of ninety miles. The fossils obtained both from this area and from the one above Bear River consist of fragments of Ammonites and Inocerami, too imperfect for specific determination.

A hundred and twenty miles below the Ramparts, the Mackenzie enters a third Cretaceous area, and the largest one on the river. Cretaceous beds appear in the banks a short distance below old Fort Good Hope and extend down the Mackenzie to the head of its delta, and westwards across the Rocky Mountains and down the Porcupine to about long. 139° W. They consist on the Mackenzie of coarse shales interstratified with some sandstones and fine grained conglomerates; in the mountains of several thousand feet of barren sandstones and quartzites underlain by dark shales, and on the Porcupine of the same two series underlain by a great thickness of alternating shales, sandstones and conglomerates, holding *Aucella Mosquensis* var. *concentrica*. The intermediate dark shales are probably of Benton age, while the lower division so far as the fossil evidence goes, represents the Queen Charlotte Island formation and the Dakota (see p. 139).

Cretaceous shales holding *Aucella* and passing upwards into fine grained conglomerates, occur on the Yukon for many miles above and below the mouth of the Tatondue (see p. 139), and were traced by Ogilvie up the latter stream for some distance. They have been greatly disturbed and are folded up in broad bands with the underlying Palaeozoic limestones.

It is highly probable that the various Cretaceous areas scattered along the Liard, Mackenzie, Porcupine and Pelly-Yukon, were originally

Cretaceous
along the
Mackenzie.

Cretaceous
rocks on the
Yukon.

connected and have been separated by denudation. This is shown by the structure of the region, by the fossil evidence so far as it goes, and by the lithological and stratigraphical resemblances which prevail throughout.

TERTIARY.

Distribution of Tertiary. Tertiary beds occur at the mouth of Bear River and occupy a basin of about thirty to forty miles in length and twenty to thirty in breadth.

Character of Tertiary. They rest unconformably on the underlying Cretaceous shales and Devonian limestones. They are lacustral in origin and consist largely of discordantly bedded sand, sandy clays, clays and gravels. Beds of purely argillaceous material usually somewhat plastic in character are also present, and seams of lignite and carbonaceous shales not infrequently constitute a considerable proportion of the section. A more detailed description will be found on page 96. The beds have an anticlinal attitude on the whole, but are usually nearly horizontal. They have a minimum thickness of 600 feet. Remains of plants are abundant in some of the beds, but no animal fossils either vertebrate or invertebrate have so far been obtained. The following list includes all the species collected by various travellers up to date:—

- Pteris Sitkensis*, HEER.
- Smilax Franklini*.
- Glyptostrobus Ungerii*, HEER.
- Sequoia Langsdorffii*, BRONGT.
- Taxodium distichum*.
- Taxites Ostriki*, HEER.
- Populus arctica*, HEER.
 - " *Richardsonii*, HEER.
 - " " var. *latior*.
 - " *Hookeri*, HEER.
- Salix Raeana*, HEER.
- Betula macrophylla*, GPT.
- Corylus McQuarrii*, FORBES.
- Quercus Olafseni*, HEER.
- Platanus aceroides*, HEER.
- Juglans acuminata*, BRONGT.
- Viburnum Nordenskioldii*, HEER.
- Pterospermites spectabilis*, HEER.
 - " *dentatus*, HEER.
- Tilia Malmgreni*, HEER.
- Phyllites aceroides*, HEER.

- Hedera MacClurei*, HEER.
Magnolia Nordenskioldii, HEER.
Calistemophyllum latum, DAWSON.
Carpolithes seminulum, HEER.
Carpolithes.
Leguminosites (?) borealis, DAWSON.
Antholithes amissus, HEER.
Pyritized and ferruginous wood of *Sequoia* and other genera.

This list is in the main the same as that published by Sir William Dawson in the Transactions of the Royal Society of Canada (Vol. VII, Sec. IV, Page 69), but it also includes some additional species collected by the writer, and since described or determined by Sir William. On the evidence of the plants enumerated above, Sir William refers the beds to the Laramie (see p. 99). This reference is not supported by the stratigraphical evidence, but is not contradicted by it. The beds occupy a separate basin and differ from the Laramie in resting unconformably on the terranes below. In this respect and also in their lithological character they are more closely allied to the Miocene lacustral deposits of the southern plains.

West of the mountains soft incoherent beds resembling those at the mouth of Bear River and probably of about the same age, are exposed along the Porcupine River in the vicinity of the Old Crow Mountains. They were first seen about half a mile above Fishing River and were traced as far as the head of the Ramparts, a distance in a direct line of forty-two miles. Opposite the Old Crow Mountains and at another point farther up the river they are interrupted by uplifts of the underlying Cretaceous shales. Like the Bear River beds they rest unconformably on the rocks beneath. They consist essentially of light coloured sands, sandy clays, clays and conglomerates, with occasional nodular beds of ironstone, and in one section held a small lignite seam. No fossils of any kind were obtained from them. They are horizontal, or nearly so, and have a minimum thickness of 300 feet. Similar beds were noticed in the interval between the Upper and Lower Ramparts, and also occur for a short distance along the river below the Lower Ramparts.

The Tertiary beds occupy basins in the older rock, and evidence an elevation of the land at the end of the Cretaceous period followed by prolonged denudation, and a subsequent depression, accompanied by the formation of the lakes in which they were laid down.

1 SUPERFICIAL DEPOSITS AND GLACIAL ACTION.

Details of the character of the various superficial deposits met with will be found in the descriptive part of the report, and it will only be necessary here to summarize the general results.

Glacial deposits on the Liard.

On the Liard River, below the mouth of the Dease, stratified sands, gravels and clays of glacial age are constantly met with, and in one or two places are underlain by sandy clays, which were doubtfully referred to the boulder clay period. The distribution of the latter is, however, very limited in the section cut by the river west of the mountains, and the gravels and sands were repeatedly observed to rest directly on the underlying older rocks. Below Portage Brûlée terraces rising in steps up to a height of several hundred feet are extensively developed, and border the river all the way to the mountains. While passing through the mountains and eastern foot-hills ordinary river valley deposits were noted. Eastern erratics were first noticed on leaving the broken plateau belt which flanks the foot-hills on the east in this latitude, and were then traced all the way to the Mackenzie. The highest point at which they were found was on the flanks of a mountain situated opposite Fort Liard, approximately in lat. 60° N., long. 123° W., where they reach an elevation of 1,500 feet above the surface of the surrounding country, or about 2,300 feet above the sea. The erratics extend much farther west than the boulder-clay, and are probably water-borne. Eastwards from the foot-hill region stratified sands and gravels rest on the Cretaceous rocks, and are exposed in numerous sections until a point about twenty miles below Fort Liard is reached. Below this the river winds for many miles through one of those filled up depressions in the boulder-clay which are so frequently met with on the area of the great plains. In this stretch stratified sands and silts only are seen. Forty miles from the mouth of the river, measuring in a straight line, the Devonian rocks rise from beneath their lacustral covering, and are soon afterwards overlain by unmistakeable boulder-clays of the ordinary type. Boulder-clays are then almost continuously exposed on to the mouth of the river.

First appearance of boulder-clay.

Alluvial beds on Slave River.

Slave River, below Fort Smith, winds through an alluvial plain all the way to Great Slave Lake, and sections of sands, clays and gravels of later age than the boulder-clay are exposed at the elbows of all the bends. The width of this plain is considerable, as Salt River, a tributary of Slave River, serpentine through it in a westerly direction for fifteen miles, and it probably extends nearly as far to the east. It is underlain partly by loam and partly by sandy soils, and contains a number of treeless areas.

¹ Republished in part from Bull. Geol. Soc. Am., vol. i, p. 540.

Some notes on Great Slave Lake are given on pages 67-71. The low ^{Terrace on Great Slave Lake.} terraces which surround this lake are interesting, as they afford evidence either of a damming up of the whole eastern end of the lake by ice, or, what is more probable, judging by the much greater heights at which they were found by Back at the eastern end of the lake than those which obtain around the western part, of significant changes in elevation. The elevation of the region bordering the Mackenzie where it issues from the lake is inconsiderable, and a rise in the level of the latter sufficient to bring it up to the higher terraces would, under present conditions be impossible, as the outlet would immediately be enlarged to a width equal to that of the lake itself. The Archaean portion of Great Slave Lake is evidently pre-glacial in its origin, as its peculiar cruciform shape, its great depth, viewed in connection with the comparatively low elevation of the surrounding country, and the precipitous shore cliffs which occur so frequently around it, are all features which can scarcely be attributed in their entirety to glacial work. It is possible, however, that the western part, which is much shallower and has low shelving shores, may have been excavated in part or altogether by a glacier forcing its way out of a previously formed basin to the east.

Hay River, which empties into Great Slave Lake near its western end and drains the country to the south-west, has evidently had a history somewhat similar to that of Niagara, but it has not yet been thoroughly explored. It was ascended as far as the Alexandra Falls, and a description of the latter and the accompanying gorge will be found on page 73.

About ninety miles south-west of the west end of Great Slave Lake, a north-easterly facing escarpment, marking a permanent rise in the general elevation of the country was crossed, while on a winter trip from Fort Providence to Lake Bis-tehò, the front and summit of which were covered with a medley of steep-sided, interlacing hills and ridges, ^{Morainic ridge.} similar in appearance to those found on the Grand Coteau de Missouri of the plains, and evidently like them of morainic origin. The depth of the snow, however, prevented a satisfactory examination. No other morainic belts or areas were noticed in this part of the district, and the surface, as a rule, is rather uniform, but swells occasionally into wide ridges of little height running in a north-north-westerly direction. The shallow depressions between the ridges are covered largely with mossy muskegs and lakes.

Proceeding down the Mackenzie from Great Slave Lake, alluvial clays form the banks for some miles, and then a boulder-clay makes its appearance scarcely distinguishable in character from the same forma-

Boulder-clay
on the Mac-
kenzie.

tion as developed in Eastern Canada, 3,000 miles distant. It occurs here as a light-yellowish, compact, arenaceous clay, filled with rounded Archean boulders, and, as elsewhere, showing little or no signs of stratification, and is traceable, with some variations in character, as far as the Lower Ramparts, or to the head of the deltaic portion of the river; and this notwithstanding the fact that less than a hundred miles below the mouth of the Liard the Mackenzie enters the flanking ranges of the Rocky Mountains, and for the next three or four hundred miles its valley is partially guarded on the east by ranges of mountains, some of which exceed 4,000 feet in height. The thickness of the boulder-clay is extremely irregular. In some of the pre-glacial depressions sections exceeding 250 feet in thickness were frequently noticed, while a few miles away the older rocks rise to the surface, and the boulder-clay blanket either thins out or completely disappears.

Dark boulder-
clay.

For some fifty miles above Bear River the boulder-clay is much darker in colour than is usually the case, and is apparently mostly derived from the dark shales of the Cretaceous and Devonian, which floor the valley. It is almost destitute of boulders, is very plastic, and is broken down by land-slips into ruinous-looking banks similar to those produced on the Saskatchewan and other rivers of the plains by the sliding of the Pierre shales. The scarcity of boulders in this reach is probably connected with the fact that the mountains east of the river are here higher and more continuous than in other parts of the valley, and afforded a more complete protection against the eastern ice invasion. North of Bear River the boulder-clays revert to their normal character.

Stratified beds
overlying and
underlying
boulder-clays.

The boulder-clay throughout the greater part of the valley is overlain by heavy deposits of stratified sands, clays, and gravels, probably lacustrine in their origin, and is underlain by a gravel terrane somewhat similar to and occupying the same relative position as the Saskatchewan gravels of the plains of Alberta and Assiniboina, but differing in containing a much greater proportion of Laurentian pebbles. These beds have a thickness in some cases of fully 150 feet, and contain well-rounded pebbles ranging in size up to eight or ten inches in diameter. They are intimately connected with the boulder-clay, and in one place were observed to alternate with it, and they seem to show that the boulder-clay period in this region was preceded as well as followed by what may be termed a lacustrine epoch, during which the surface depressions were filled with extensive lakes.

Direction of
ice flow.

The few facts observed in regard to the direction of ice flow in the Mackenzie valley support the theory of Dr. Dawson as to its northerly movement. In the western part of Great Slave Lake the direction of

the ice current, as stated on page 76, was due west. Five degrees farther north well marked glacial striæ, striking 15° north of west, were observed crossing the summit of Roche Carcajou. This rock, which must have been completely submerged, rises to a height of 1,000 feet above the surface of the river. Important evidence on the same point is also afforded by the fact that the boulder-clay near the Lower Ramparts of the Mackenzie is in approximately the same latitude as the northern boundary of the Archæan area to the east, and the gneissic boulders which it contains must have travelled either straight west or north-west in order to reach their present situation. These facts allow the inference that the ice from the Archæan gathering grounds to the east poured westwards through the gaps and passes in the eastern flanking ranges of the Rocky Mountains, until it reached the barrier formed by the main axial range, and unable to pass this, was deflected to the north-west, in a stream approximating 1,500 feet in depth, down the valley of the Mackenzie and thence out to sea.

In crossing the mountains by the Peel River Portage few glacial ^{Terraces.} features were noticed. A couple of terraces, the higher of which has an elevation of about 550 feet above the sea, flank the range on the east, and a sub-angular gneissic erratic was found at a height of 1,500 feet, but this was probably water-borne. On the western side of the mountains a terrace, with fragments of a higher one resting on it in places, was crossed at an elevation of about 1,500 feet above the sea. Proceeding down Rat River to the Porcupine, and down the latter through the ramparts, sands, gravels and silts are found resting on the underlying rocks, but no boulder-clay, perched boulders or other evidence of glaciation were anywhere seen. Along the upper part of the Ramparts river gravels, often very coarse in character, were noticed at various points up to elevations of 400 or 500 feet above the surface of the river. Some miles below the Ramparts the banks of the valley ^{Great plain} diverge on either side, and enclose a great plain through which the Porcupine serpentines all the way to the Yukon, a distance measured in a straight line of about seventy-five miles. This plain has a width in its widest part of fully ninety miles. Sections are cut through it in different directions both by the Porcupine and Pelly-Yukon, and show it to be underlain throughout by stratified sands and silts, often showing false bedding and with occasional layers of gravel. The latter appeared to become finer-grained and of less relative importance towards the centre of the area. The size of the plain, its uniformity and the character of the beds which underlie it suggest a delta origin, and correlate it with the lowlands at present in course of formation at the mouth of Slave River in Great Slave Lake. It is probable that a lake basin

or great dilatation in the channels of the Porcupine and Yukon once existed here and has been obliterated by the deposition of the detritus brought down by the two streams, or, as suggested by Russell,* the facts may be explained by a damming back of the Yukon by recent orographic movements.

The Yukon, above its junction with the Porcupine, winds through the alluvial or lacustral plain which has just been described for a distance of seventy miles. Above this the valley becomes more contracted, and is floored with the older rocks or the ordinary river wash. Opposite the International Boundary a terrace was noticed by Russell at a height of 734 feet above the level of the river. Above the boundary fragments of similar high terraces, usually somewhat indistinct, occur at several points, and rolled gravels were found at varying heights opposite all our camps. Thirty miles below the mouth of the Pelly rolled gravels, evidently derived from broken down terraces, were found in some abundance up to a height of 800 feet. From the Stewart River upwards, terraces of a more recent date, ranging up to a hundred feet in height, border the river at intervals and increase in elevation as we ascend, but no boulder-clay or other evidences of glaciation were seen until a point about seven miles below the Rink Rapid was reached. Above this signs of glacier action, as previously pointed out by Dawson, are unmistakeable. The plateau bordering the Pelly-Yukon was not examined, but, judging simply from the records of the Ice age which the valley itself affords, it would appear that the glacier which undoubtedly filled the upper part of the valley of the Lewes and moved northwards did not descend much below lat. $62^{\circ} 24' N.$ Below this the deposits indicate a flooded valley, but nothing else.

A feature of some interest in connection with glacial phenomena, and which may have some bearing on the non-glaciated condition of part of Alaska and the adjacent portion of the North-West Territory of Canada, is the fact that glaciers are unknown in the Rocky Mountains north of the headwaters of the Athabasca, or about lat. $54^{\circ} N.$ North of this occasional patches of snow survive the summer in sheltered nooks, but even these decrease in frequency with increasing latitude, and on the Peel River portage, in lat. $67^{\circ} 20' N.$, the snow had entirely disappeared before the middle of July. Also, in descending the Porcupine and ascending the Yukon, no snow was seen until far up the Lewes, and no glaciers until the head waters of this stream were reached. It follows from this that climatic changes which would extend the present glaciers of the Bow and Saskatchewan far down

Terrace oppo-
site boundary

Limits of
glacier

Absence of
glaciers in
mountains.

* Bull. Geol. Soc. Am., Vol. I, p. 114.

their valleys might have little or no effect in imposing glacial conditions on this more northern region.

ECONOMIC SYNOPSIS.

GOLD.—As a full account of the discovery of gold and the progress and present condition of gold mining in the Upper Liard, Cassiar and Yukon districts is given by Dr. Dawson in the Annual Report of the Survey, 1887-88, Part B., pp. 78-86 and 178-183, it will be unnecessary to go into the subject in detail here. “Colours” of gold occur in the bars ^{gold on the} Liard all the way to its mouth, but no deposits of economic value have been found below the Devil’s Portage. A number of bars were worked, between the Devil’s Portage and the mouth of Dease River, for several years after the discovery of gold on the Liard by Messrs. McCulloch and Thibert in the year 1872, but these are now all abandoned and the records of them lost. At the present time no miners are employed on the Liard below the mouth of Dease River.

Gold in paying quantities has not been found on either the Mackenzie or the Porcupine, and the rock formations bordering these rivers do not appear to be gold-bearing.

On the Pelly-Yukon above the Boundary, and as far as the mouth of the Pelly, the limit of my examination, gold in varying quantities is of almost universal occurrence, but up to the present time active operations have been confined almost entirely to two of the tributaries. Of these Forty Mile Creek enters the Pelly-Yukon from the west, about forty miles above the boundary and has its course mostly in Alaska, while Stewart River comes in from the east and flows through Canadian territory all the way. Gold was discovered on the Stewart in 1885, and in that and the following year the estimated yield of the various bars amounted to over \$100,000, but in 1887 it was almost deserted owing to the discovery of coarse gold on Forty Mile Creek, and the consequent “stampede” of the miners to that stream. The gold on the Stewart is ^{Stewart River.} reported to be “fine,” and the bars are often exhausted under present conditions in a single season’s work, but as they are abandoned when the yield falls much below \$10 a day per man, it is highly probable that work on many of them will be resumed when improved methods of mining are introduced, and the present exorbitant prices for labour and provisions are reduced. Extensive gravel benches of a more or less auriferous character border the Stewart in many places, and promise remunerative returns if worked on a large scale.

Forty Mile Creek proved a veritable bonanza to most of the miners ^{Forty Mile Creek.} who reached it early in 1887, but in 1888 the returns, owing to the

continued high water, were disappointing. In the former year the yield has been estimated all the way from \$75,000 to \$150,000 and was probably in the neighbourhood of \$100,000. In 1888 the yield in consequence of the enforced idleness of the miners, declined to less than \$20,000, most of which was obtained from the upper or Alaskan part of the stream. The number of miners employed on the stream during the two seasons varied from about 100 to 350. The gold on Forty Mile Creek is coarser than that obtained from the Stewart, but the auriferous bars are usually of little depth and are soon skimmed over. Some attention was paid during the season of 1888 to prospecting the gulches and gravel terraces bordering the stream, but these have not been worked as yet to any notable extent.

Quartz veins. The country rocks bordering the Pelly-Yukon, all the way from the boundary to White River and beyond, consist of schists broken through by eruptive granites and diorites, geological conditions peculiarly favorable to the existence of metalliferous deposits. (See p. 140.) They are traversed in many places along the river by promising quartz veins and ledges, but these have been very little prospected as yet, the miners contenting themselves up to the present with the development of the more easily worked placer deposits.

Argentiferous galena. SILVER.—A small lode of argentiferous galena crosses Forty Mile Creek a couple of miles above its mouth. A specimen of this brought back by Mr. Ogilvie and analyzed by Mr. Hoffmann yielded over 38 oz. of silver to the ton.

Copper Pyrites. COPPER.—Copper pyrites, in small quantities, was noticed at several points between Forty Mile Creek and Fort Reliance. It does not occur in veins, but appears to impregnate individual layers of the schist itself. Traces of copper were also observed in the Castle Mountain dolomites at the base of the Nahanni Butte section.

Asbestos. FIBROUS SERPENTINE.—Some of the serpentines in the vicinity of Forty Mile Creek occasionally assume a fibrous structure and pass into a picrolite or coarse asbestos. A small specimen of good serpentine asbestos has also been brought from the Stewart River, (see Annual Report Geol. Survey, 1887-88, p. 27 B).

Gypsum. GYPSUM.—Gypsum occurs in large quantities in the Devonian rocks of Bear Mountain at the mouth of Bear River (see p. 102).

Salt springs. SALT.—Several salt springs drain into Salt River, near Fort Smith, about twenty-five miles above its mouth. Some of the springs have basins ten to twelve feet in diameter, which are encrusted with crystalline salt of excellent quality (see p. 65). Salt is also reported to occur on the head-waters of a small stream which enters the Mackenzie about fifty miles above Fort Norman.

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SULPHUR.—Mineral springs of large volume occur at Sulphur Point, Sulphur spring, on the south shore of Great Slave Lake, and also at the tar springs, north of Point Brûlé on the north shore. In both cases small quantities of sulphur are deposited in the basins of the springs and along the channels of the streamlets which drain them.

COAL.—Small seams of impure lignite were found on the Liard, a ^{Lignite.} few miles above the Little Cañon, and large blocks of drift lignite occur on the same stream at the mouth of Coal River. On the Mackenzie the Tertiary beds at the mouth of Bear River hold several seams of lignite, ranging in thickness from two to four feet, and one seam which was concealed at the time of my visit, is reported by Richardson to be nine feet thick. The lignite here is of inferior quality, and has been burnt in many places for some distance from the surface by fires which have been in existence since the river was first discovered. West of the mountains a small seam of lignite was observed on the Porcupine, a few miles above the mouth of Old Crow River, and seams of coal are reported to occur in a small stream which enters the Pelly-Yukon from the east below Forty Mile Creek. The latter is probably of Cretaceous age.

PETROLEUM.—The Devonian rocks throughout the Mackenzie valley ^{oil bearing beds.} are nearly everywhere more or less petroliferous and over large areas afford promising indications of the presence of oil in workable quantities. The rocks in several places around the western arm of Great Slave Lake, are highly charged with bituminous matter, and on the north shore tar exudes from the surface and forms springs and pools at several points (see p. 77). The tar from these springs is used by fur traders and others in the country for pitching boats and canoes, and they report that a pool when exhausted quickly renews itself. In descending the Mackenzie bituminous limestones were noticed at the "Rock by the River Side," at Bear Rock, at the Ramparts, and at numerous other places. Near Fort Good Hope several tar springs exist, and it is from these that the Hudson's Bay Company now obtain their principal supply of pitch. The springs are situated at some distance from the river and were not examined. Still farther down, in the vicinity of old Fort Good Hope, the river is bordered for several miles by evenly bedded dark shales of Devonian age which are completely saturated with oil. The shales here have been reddened in many places by the burning of the oil which they contain (see p. 111).

The possible oil country along the Mackenzie valley is thus seen to be almost co-extensive with that of the valley itself. Its remoteness from the present centres of population, and its situation north of the

still unworked Athabasca and Peace River oil field will probably delay its development for some years to come, but this is only a question of time. The oil fields of Pennsylvania and at Baku already show signs of exhaustion, and as they decline the oil field of northern Canada will have a corresponding rise in value.

CLIMATE AND AGRICULTURE.

Climatic statistics.

In the region in the vicinity of Great Slave Lake and down the valley of the Mackenzie for two or three hundred miles, spring weather generally sets in about the last week in April or the first week in May, and by the 15th of May the snow has usually disappeared and vegetation has begun. The summer temperature, as a rule, is moderate, the thermometer rarely rising much above 70° F. in the shade, or sinking below freezing point. The warm weather lasts about four months only, and by the middle of September is practically over.

Frozen soil.

Around Great Slave Lake the soil seldom thaws out to a greater depth than eight feet, and in many of the muskegs and marshes ice remains throughout the year at a depth of about two feet. In descending the Mackenzie the frozen soil gradually approaches the surface. At Fort Norman at the end of summer it lies at a depth of about six feet, at Fort Good Hope at about four feet, and at the mouth of Peel River at about two feet. The thickness of the frozen stratum was not ascertained.

Character of winter.

Winter sets in about the middle of October and lasts for fully six months. In the autumn of 1887 the first snow fell at Fort Providence on the 1st of October, on the 21st of October ice was drifting in the river, and on the 16th of November the Mackenzie was frozen across. The winters are characterized by their steady cold weather. In 1887-88 the thermometer did not rise above freezing point between the 4th of November and the 20th of April, and from the 1st of December to the 1st of March was usually 20° or more below zero. The coldest dip of the season occurred on the 13th of February, when the thermometer marked 48° below zero. The winter winds are seldom very strong, and are generally from the N.N.W. or N.E. The precipitation is light, but no accurate records of it have been kept. In the season of 1887-88 the snow accumulated on the ground to a depth of about three feet. This represents the total snowfall as no thaw occurred between the 29th of October and the 1st of May.

Agricultural capabilities.

The agricultural capabilities of a region in which the snow lies on the ground for nearly seven months in the year, and in which the soil never thaws out to a greater depth than six or eight feet, are necessarily limited, but that crops of various kinds will mature even under

these unfavorable circumstances has been proved by the experience of over a quarter of a century. At all the posts of the Hudson's Bay Company, along the Mackenzie and its tributaries, with the exception of Fort Macpherson, small plots of land are annually cultivated and large quantities of potatoes, turnips, beets and other vegetables are grown for use in the district; while at Fort Liard and Fort Providence, the two most southerly posts in the district, both wheat and barley, have been tried with success (see p.p. 54D and 78D). There is, however, little reason to hope that the Mackenzie River district as a whole, or even the southern part of it, except in limited areas, will ever be able to support a purely agricultural community, or that its products will ever be able to compete in the open markets of the world with the produce of more favoured regions. Its agricultural development will depend on a local market being obtained. When the time comes, as come it must, when the undoubted mineral resources of the region are drawn upon, the food required by the mining population, or the greater part of it at least, can be supplied locally.

The amount of arable land is small compared to the total area, and is mostly confined to the vicinity of the larger streams. Away from the rivers frozen marshes and muskegs, and shallow lakes cover the greater part of the surface. The alluvial lands along Slave River, the upper part of Mackenzie River, and the country bordering the Liard for some distance above and below Fort Liard and west of the mountains, are the best parts of the district. The lower part of the Mackenzie valley and the country along the Porcupine and the Pelly-Yukon below Fort Selkirk afford little prospect of ever becoming of agricultural value.

DESCRIPTION OF ROUTES.

LIARD RIVER.

Mouth of Dease River to the Devil's Portage.

The Liard River is one of the three principal tributaries of the Mackenzie, the other two being the Athabasca and the Peace. It has ^{general description of river.} its sources west of the Rocky Mountains, one of its branches reaching to within one hundred and fifty miles of the sea, and drains the eastern part of the broken country lying between that range and the coast mountains. Its branches spread through four degrees of latitude, from 58° N. to 62° N., and interlock with those of the Yukon, Stikine, Skeena, and Peace Rivers. In its upper part it divides at intervals into four nearly equal streams, the Mud or Black River, Dease River,

Francis River, and the branch which retains the common name. Of these the latter and Black River are still practically unknown. Dease River and Francis River were examined by Dr. Dawson in 1887, and the following account treats of the main river from its junction with the Dease to its mouth, a distance of about 470 miles. Rising in the elevated country west of the Rocky Mountains, the Liard falls rapidly towards the east, the difference in elevation between the mouth of the Dease and the Mackenzie amounting to nearly 1,650 feet, and is characterized nearly everywhere by impetuous currents, by dangerous rapids and narrow whirlpool-filled cañons. The descent of the river is greatest and its rapids most numerous, while passing through and for some distance on either side of the Rocky Mountains. After leaving the foot hills it is nearly free from interruptions until near its junction with the Mackenzie, where a series of strong riffles occurs.

The Liard River was used for a number of years by the H. B. Co., as a trading route to the Yukon, and a line of posts extending from¹ Fort Simpson on the Mackenzie, to Fort Selkirk at the junction of the Lewes and Pelly was established by them, but the expenses incurred in overcoming the great length of difficult navigation made the trade unprofitable, and most of the posts have been long since abandoned. At the present time a trading post exists at the mouth of the Dease, but it is supplied from the Pacific by way of the Stikine and Dease River. The Liard has also been used to some extent by prospectors and miners, the discoverers of the Cassiar Gold fields, Messrs McCullough and Thibert having ascended it from Fort Simpson to the mouth of the Dease in 1871-72.

Liard River
used as a trade
route by H. B.
Co.

Early notices
of river.

Information in regard to the Liard previous to the present exploration was exceedingly limited, as notwithstanding the use which had been made of it by both fur traders and miners, no survey of the river had ever been made, and its course as laid down on existing maps was found naturally to be extremely incorrect, in some places being fully one hundred miles out of position. The best sketch of the river I could obtain was one drawn for me from memory by Mr. Thibert who had ascended the river eighteen years before. The published descriptions also were of the vaguest hearsay character. Sir J. Richardson gives a few notes in regard to the lower part in his "Journal of a Boat Voyage through Rupert's Land," and L'Abbé E. Petitot writes of it in the following manner:—

"Je n'ai remonté la rivière des Liards que de quelques milles, mais tous les voyageurs qui y ont navigué s'accordent à faire une description effrayante de ses montagnes à pic, de ses gouffres et des tourbillons que la vitesse d'un

¹ Bulletin de la Société de Géographie, Paris, 1875.

ne. Of Dease 7, and in the rapidly of the s char- gerous e river rough. After ear its Co., as n' Fort Lewes a over- unpro- At the it is . The miners, h and of the plora- I been er had s was fully river I t who scrip- rdson of a writes s tous yante d'un

courant resserré entre des rochers, détermine dans ses eaux. Pour descendre cette rivière vertigineuse avec sécurité les timoniers métis se lient sur le pont de leur barque, afin de n'être pas lancés dans les flots blanchissants. Pour retrouver un tel spectacle il faudrait affronter les périls de Charybde ou les girations intermittentes de Maelstrom."

The present survey is only intended as a provisional one, and was made by estimating the rate according to measurements made at intervals along the shore and taking the bearings with a prismatic compass. Observations for latitude were also taken whenever practicable, and serve as a useful check on the traverse.

We left the mouth of Dease River on the 26th June, in a small wooden boat which was built by ourselves on Dease Lake. The party consisted besides myself of two white men, Louis Trépanier and John McLeod. Besides these, I also engaged a couple of Indians to accompany us as far as the Devil's Portage, but they deserted at the first difficulty which presented itself. The natives along this part of the Liard are very inferior canoemen, and are afraid to venture on the river except in its smoothest portions. They seldom ascend the river with canoes, as they prefer carrying their outfit along the shore to tracking a boat against the rapid current, and in descending use small spruce bark canoes which they can build in a couple of hours and abandon without much loss. They belong to the Kas-ka branch of the great Tin-né family, and are commonly referred to as the Grand Lake Indians.

The Liard River below the mouth of the Dease has a general width of from two hundred and fifty to four hundred yards, but widens out in places to over half a mile, and a current of four miles and a half an hour. It separates in places into a number of channels enclosing low alluvial islands usually well wooded. Its valley is from two to three miles wide, and is shallow with rolling banks sloping easily up to the general level. The country is everywhere well wooded, but the trees are usually small, seldom exceeding a foot in diameter. The principal varieties observed were the black pine (*Pinus Murrayana*), the White spruce, (*Picea alba*), and the smooth and rough barked poplars, (*Populus tremuloides* and *balsamifera*.) Besides these, groves of larch were occasionally seen, and some varieties of willow and alder. Twelve miles below the mouth of the Dease the Liard receives a large tributary from the north. This stream is over a hundred yards wide, and is called the Highland River, after a prospector who ascended it for some distance. On the older maps it is named the McPherson River. In the direction from which it comes are some low hills at a distance of four to five miles, behind which appear snowy mountains. From the mouth of Dease River the Liard runs in a general E. S. E. direction for eight

Character of survey,

begin descent of river

Indians along river.

Width of river and valley.

Bordering forests.

Hightland River.

teen miles, and then making a sharp bend to the north, runs for about the same distance in a direction nearly at right angles to its former course. Below the bend the river for twelve miles is wide and filled with islands, after which it gradually decreases in width, and this, with the steeper slopes of the valley and the increasing strength of the current, which occasionally breaking into small ripples now hurries along at the rate of seven miles an hour, all afford signs of our approach to the Little Cañon, of the dangerous character of which we had been previously warned, and which soon comes into view.

Little Cañon.

The Little Cañon is about half a mile long, and in its narrowest place about two hundred feet wide. It is easily navigable in low water, but is dangerous for small boats during flood, as the channel is very crooked, and the current striking with great violence against the right hand bank is thrown forcibly back, with the production of a number of breakers running nearly lengthwise with the direction of the channel, and large enough to swamp any ordinary river-boat which is drawn among them. A number of Chinamen were drowned at this point some years ago. This cañon can be run with safety by entering it nearly in the middle of the stream, which is as close to the left hand bank as the lines of reefs and isolated rocks running out from that side will allow, and once past these making all haste to the left so as to clear the breakers below. In high water the rapid can be avoided by making a portage of about half a mile along the right bank.

*Rocks between
Dease and
Little Cañon.*

Rock exposures are infrequent in the valley of the Liard between the mouth of the Dease and the Little Cañon, but those observed will be described in order. Three miles below the mouth of the Dease is a small exposure of somewhat soft dark shales associated with friable sandstones and conglomerates. A second exposure of the same beds was observed about a mile farther down the river, where they dip N. 60° W. $< 20^{\circ}$, beyond which they disappear. These rocks are unfossiliferous, but from their lithological characters, and the fact that they overlie unconformably the hard quartzites, slates, and limestones, of the neighborhood were referred to the Tertiary. At the mouth of Highland River, on a small island is an exposure of hard whitish sandstone, passing into quartzite. This rock weathers yellow, and dips N. 50° E. $< 50^{\circ}$. Six miles further down, at a bend which the river makes to the north, is a cut bank showing unconsolidated sands, sandy clays and gravels, and holding some small beds of impure lignite. Below this, with the exception of rolled river gravels, no further exposures were seen until near the Little Cañon, when black shales appear in a couple of places.

The rocks in the Little Cañon consist of dark and sometimes cleaved

shales, holding large flattened ironstone nodules, hard sandstones and quartzites, and some beds of fine grained hard siliceous conglomerate. They are closely folded together and strike N. 35° W. No fossils were found in any of these beds, nor any definite evidence of their age obtained beyond the fact that the shales have a close lithological resemblance, both in appearance and composition, with those on Dease River, from which Dr. Dawson obtained graptolites of Utica-Trenton age.

Below the Little Cañon the river widens out to over half a mile, and the steep, rocky banks are replaced by easier slopes of gravel and sand. These continue for three miles, after which shales and sandstones reappear in the bank, and their confining influence is immediately seen in the rapid contraction of the stream and the formation of a second narrow. These sudden dilatations and contractions constitute one of the most characteristic features of the Liard, and are an indication of the heterogeneity of the formations through which it cuts. Through the defile just mentioned the stream rushes with great velocity, but with an even current until near its foot, where it is forced between two points of rock scarcely a hundred feet apart, which project into the stream from either bank and determine the formation of two rapidly gyrating and dangerous looking whirlpools. These can be avoided, if necessary, by making a portage of a few feet across one of the points. In ordinary stages of the water, however, they can be run without difficulty.

At this point the shales, sandstones and conglomerates which have been exposed at intervals all the way from the mouth of the Dease, are replaced by shaly limestone and soon afterwards by more massive varieties of the same rock.

Beyond the narrows, the river at once resumes its ordinary dimensions, and rushing rapidly around a short bend enters one of the most picturesque portions of the valley of the Liard. The river here averages about three hundred yards in width, and glides along with a strong even current of about five miles an hour. It is narrowly confined by sloping banks, which follow closely all the bendings of the stream, without any intervening flats, or, except at low water, any disfiguring bars and beaches. The valley is everywhere densely wooded with evergreens, aspens, birch and alder, the changing greens of which are agreeably relieved at intervals by grey limestone cliffs, which rise steeply from the water's edge, and ruffle the surface of the otherwise glassy stream.

Eight miles below the entrance to this portion of the river is situated Porcupine Bar, once the scene of active mining operations, but now worked out and abandoned. Opposite to it is a range of low hills, at the base of which I camped somewhat early on the afternoon of the 28th, for the purpose of ascending them and so obtaining a view of the surrounding country.

Appearance of country.

These hills extend in an irregular manner for some miles along the left bank of the river, but appear to have no definite strike. They have the rounded outlines, which characterize all glaciated districts, but no striae were anywhere observed. They are composed of limestone and have an altitude of 1,500 feet above the river, or one thousand feet above the general plateau level. From their base stretches in all directions, an irregular rolling plateau, broken here and there by ranges of low hills and dotted with innumerable small lakes and marshes. To the south the horizon is broken by the serrated crests and jagged summits of the Cassiar range, one prominent peak bearing S 20° W. In a direction N. 25° W., at a distance of twelve to fifteen miles are some low hills still covered with streaks of snow, while a range of partially snow-clad hills were also seen at S. 26° E. The plateau is everywhere densely wooded, the principal trees observed being the white spruce, the black pine, the larch, the rough and smooth barked poplars, the birch, and species of alder and willow. Of these the spruce, which obtains here a diameter of fifteen to twenty inches, is by far the most abundant and valuable.

Character of limestone.

The limestone of which the hills are formed is usually greyish in colour and rather compact, but passes in many places into a whitish highly crystalline variety without distinct bedding. It has a general strike of N. 15° W. It is destitute of determinable fossils, but holds fragments of crinoid stems, and traces of brachiopods and trilobites.

River below Porcupine Bar.

From Porcupine Bar the river runs S.S.E. for some miles, and then bending more to the south, preserves a general southerly direction for ten or twelve miles, when it is closed in by a nameless cañon. In this reach it presents much the same features as those noted above, but its valley is somewhat wider, and is now bottomed by long narrow well wooded flats. Also the bed of the river becomes considerably enlarged in places and divides around a number of alluvial islands. The banks of the valley have an average height of five hundred feet and show frequent exposures of whitish coarsely crystalline, greyish, fine grained limestone, striking a few degrees west of north and dipping at all angles. Four miles and a half below Porcupine Bar, is Bed-rock Bar, now like the former deserted. Eight miles farther down is another abandoned miner's camp now represented by a single log hut. Passing this, the river bends more to the north and divides around a rocky island, on either side of which is a short riffle, then runs with an even current of about four miles an hour to the cañon mentioned above.

This cañon is scarcely a hundred yards in length, and is bounded by precipitous limestone cliffs about one hundred and fifty feet apart. It presents no obstacle to navigation. Immediately below the cañon the

river dilates for some distance into a large island-filled basin, beyond which it contracts again to its ordinary width of three or four hundred yards, and runs with a swift even current in an easterly direction for five miles, when its course is interrupted by the Cranberry Rapids.

The limestones seen along this part of the river are often coarsely crystalline and cut up by white calc spar veins. Other varieties show wavy lines projecting from weathered surfaces due to alternating magnesian and calcareous layers, and closely resemble in this respect the limestones of the Castle Mountain group as developed along the Bow River Pass. In some places the limestone becomes shaly and impure, and is altered into an imperfectly developed schist. Character of limestone.

Two miles above Cranberry Rapids the limestones are replaced by shales, sandstones and conglomerates, and a change is immediately noticeable in the character of the stream. The declivity is greatly increased and for the next fifty miles rapids are of constant occurrence. Limestones replaced by elastic rocks.

The rough water at Cranberry Portage has a total length of a mile and a half, but there is a reach of comparatively undisturbed water about half way down. The upper part of the rapid is exceedingly wild, as the bed of the river is filled with huge angular masses of rocks against which the current breaks with frightful violence. No part of the channel is clear and a glance at the forbidding array of foaming breakers and whirling eddies, showed at once the utter hopelessness of any attempt to run it with our small heavily laden boat. We passed it by portaging our outfit about half a mile along the right bank, and then dropping the empty boat with a rope, and at the worst places dragging it across points of rock. The lower part of the rapid is not so rough, and we managed to work our boat through without unloading. Rapids at Cranberry Portage.

The rocks at the Cranberry Rapids consist of shales, sandstones and conglomerates closely resembling those observed at the Little Cañon and evidently of the same age. The shales are dark, finely laminated, and occasionally show well marked cleavage lines. They are interstratified in places with the sandstones, and often enclose flattened ironstone concretions, a number of which were broken, in a resultless search for fossils. The sandstones, lighter colored than the shales, are hard and often pass into quartzites. The conglomerates are very fine grained and consist principally of white well rounded quartz pebbles imbedded in a siliceous matrix. The shales and accompanying beds are broken through and altered to some extent by a series of dykes. They have a general easterly strike and lie at all angles from horizontal to vertical. On the opposite side of the river an exposure of soft shales and conglomerates resting unconformably on the beds just described, and evidently of Tertiary age, was observed, but was not closely examined, owing to the impossibility of getting across to it. Rocks at Cranberry Portage.

Below the rapids the river hurries on with a smoother surface, but with scarcely diminished velocity, its strength being shown by the way it foams around the occasional rocky obstructions in its course. It is bordered for some distance by large eddies between which and the downward current are long lines of dangerous looking whirlpools. Farther down is a long but easily navigable riffle, beyond which, with the exception of an occasional rock, the channel remains comparatively clear until the stream variously known as Black, Mud, or Turnagain River is reached.

Mud River.

This stream, although one of the principal affluents of the Liard, is at present almost unknown. It originates near the Findlay branch of the Peace River and joins the Liard after a course of about two hundred and fifty miles. At its mouth it is over one hundred and twenty yards wide. Eighty miles above its mouth is situated a small trading post, built some years ago by Mr. Rufus Sylvester, but now in the possession of the Hudson's Bay Co. This post is connected with the central post at the mouth of McDame Creek on Dease River by a pack trail about seventy miles long.

Mountain Portage Rapids

From Mud River the Liard bends more to the north, and still running with great rapidity and breaking into occasional riffles, reaches, in a couple of miles, the Mountain Portage Rapids, one of the worst rapids met with on the trip. The river here falls over a band of shales irregularly hardened by a system of dykes and worn into a succession of ridges and hollows, and the roughened surface thus produced throws the hurrying waters into an indescribable turmoil. We landed at the head of the rapids on the right bank and were forced to spend a day in making a difficult portage of about half a mile with both boat and outfit. I afterwards learned from W. Lépine, an old Hudson Bay voyageur, that we might have avoided this portage if we had landed on the left hand side, as what we supposed was the mainland was really an island, behind which a small channel existed which can be run with comparative safety.

Rabbit River.

Half a mile below Mountain Portage, Rabbit River comes in from the south. This stream is about two hundred feet wide and brings in a large volume of clear water. At its mouth is a large auriferous bar, which has evidently been worked by placer miners to a considerable extent. I was, however, unable to obtain any information in regard to it. Below Rabbit River the channel is clear for a couple of miles and then dancing white-caps on ahead indicate the presence of another rapid. In the next mile the river alternately narrows in and expands three times, and falls over short but strong riffles at each constriction, all of which can easily be avoided, if necessary, by

making portages a few yards in length. The behaviour of the water in the dilated basins between the narrows is somewhat peculiar, as it seems, viewed from the bank, to be running in all directions and to be split into a network of cross currents. At the lower narrows three ugly looking whirlpools are formed by the rapidly contracting stream endeavouring to crowd its way through its narrowed channel, while the water sucked down by the whirlpools is thrown up a little farther down in huge boils and with a sound resembling the rumbling of distant thunder. The whirlpools occur near the left side and can be passed in safety by keeping to the right bank.

From Cranberry Portage to Whirlpool Cañon, the point now reached in the description of the river, numerous exposures of the same shale sandstone and conglomerate series previously described are everywhere present, and to the heterogeneity of this formation are mostly due the numerous rapids which occur on this portion of the river, the harder bands narrowing in and damming back the stream, while the softer and more easily eroded parts have acquired a more uniform slope. The shales and associated beds are everywhere greatly disturbed and usually dip at high angles. They have a general southeasterly strike. At Whirlpool Cañon the shales disappear and are replaced by a shaly variety of limestone.

From Whirlpool Cañon the river flows swiftly around a sharp bend, at the extremity of which it receives Coal River, and after a clear course of less than four miles, plunges over the rapids at Portage Brûlé.

Coal River is a small, clear stream about a hundred feet wide, and is interesting on account of the quantity of lignite which it brings down. At the time of our visit a bar at its mouth was thickly strewn with large angular and apparently little-travelled blocks of this mineral. The fresh appearance of the lignite induced me to spend part of a day, while the men were packing across Portage Brûlé, in exploring for the bed from which it originated, but a walk of several miles up the stream failed to reveal its presence *in situ*, although an abundance of drift fragments was everywhere noticed. The lignite is of inferior quality. It is soft and shows a well-marked woody structure. The banks of Coal River, as far as my examination extended, are low, and consist of uncemented sands, clays and gravel, like those holding the lignite beds above the Little Cañon. This formation is of irregular thickness, but of wide distribution, as it was observed filling depressions in the older rocks all the way from the mouth of the Dease to the passage of the Rockies.

Portage Brûlé is nearly two miles long, and leads across a nearly level, well wooded flat, which, at the upper end of the portage, is only elevated a few feet above the surface of the river, but at the lower end

is terminated by a sharp descent of over two hundred feet. A good track was cut across this portage when mining was being prosecuted on the Liard, and a windlass built at the east end for the purpose of hoisting boats up the steep bank, both of which are still in good condition. It was at the lower end of this portage, in the year 1836, that a party of Hudson Bay voyageurs, bound on a trading expedition to the Stikine, after carrying their packs up the hill, were seized with a panic caused by the supposed approach of a band of hostile Indians, and, abandoning their outfit, fled for safety down the river. In the succeeding year Mr. Robert Campbell found the goods in the same position in which they had been left.

Rapids at Portage Brûlé. The rapids at Portage Brûlé do not look so formidable as those at the Mountain Portage, and if I had examined them before making the portage I would have been strongly tempted to try and run them with the empty boat. They are about two miles long, and are caused by numerous limestone blocks and small islands obstructing the channel. At the lower end the river is narrowly confined by high vertical cliffs.

Rocks between Whirlpool Cañon and Portage Brûlé. The rocks observed along the river from Whirlpool Cañon to the lower end of Portage Brûlé consist altogether of different varieties of limestone. This occurs in some places in massive beds, ranging in texture from compact to moderately crystalline. In other places it becomes very impure and shaly, and often passes into imperfectly developed calc schists. No fossils were obtained from it, but it has a close lithological resemblance to the limestone, occurring above Cranberry Rapids, and to the Castle Mountains group of the Bow River section, and is probably of Cambro-Silurian age.

River below Portage Brûlé. After freeing ourselves from the rapids at Portage Brûlé, no farther obstacles to navigation were encountered until the Devil's Portage was reached. The river is wide and filled with low islands and bars, some of which are auriferous. McCullough's Bar, on which gold in paying quantities was first discovered on the Liard, occurs in this vicinity, but I was unable to identify it. The river valley is now lined with rows of terraces rising up to a height of several hundred feet, and clothed in unwooded portions by a luxuriant growth of grasses and vetches as I have ever seen in any part of the country. Behind the terraces is a gently undulating region, occasionally swelling into elevations of from 1,200 to 1,500 feet in height, and everywhere densely forested, chiefly with white spruce. To the eastward the elevations increase in height and frequency until they merge into the range of the Rocky Mountains, the dim outline of which can now be seen along the eastern horizon.

Terraces along river. Agricultural prospects. This part of the country judging from the luxuriance of the vegetation and the character of the soil, seems well adapted for agricultural purposes, but the complete absence of climatic statistics render any pos-

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tive statements in this connection premature. On the present trip at the Little Cañon, large snow banks were observed in sheltered places along the banks of the river as late as the 28th of June. It must be borne in mind, however, that the spring of 1887 in this part of the country was an exceptionally late one.

Ten miles below Portage Brûlé, Smith River comes in from the north. This is a small stream about one hundred feet wide, and appears to originate in a north-westerly spur from the Rocky Mountains, visible in the distance. At its mouth was situated Fort Halkett, a ^{Fort Halkett.} Hudson's Bay trading post which has been abandoned since 1865. I found no traces of the post.

Near the mouth of Smith River, a number of exposures of dark shales were observed. These shales are much softer than those seen farther up the river, and are probably of Mezozoic age. They were traced down the river for several miles, and are then replaced by limestones. No fossils were found in them.

From Fort Halkett the mountains appear quite close and the river ^{River below} runs swiftly in an E. S. E. direction straight towards a narrow gap ^{Fort Halkett.} which now appears in their ranks. Before entering this we pass, on the right-hand side, the mouth of Rivière des Vents. This river comes from a large lake a few miles south of Fort Halkett, from which the fish supply of the post was obtained. It cuts off from the main range a steep sided, massive looking mountain, which I named Mt. Reid in honour of Mr. Reid, the Hudson's Bay officer at present in charge of Fort Providence and an old traveller in these regions. From Rivière des Vents we approached the gap cautiously, on the lookout for the Devil's portage and rapids, which were reported to exist in its neighbourhood, but, much to our surprise, passed through without hindrance, and in a few minutes found ourselves among the rolling foothills on the eastern side of the range. The mountains here are narrowed to a single range, and even this, a few miles north of the river, is so reduced in height that it can scarcely be distinguished from the ordinary ridges of the district. To the south the range is much wider and the river seems to skirt the northern extremity of what may be considered the main division of the Rocky Mountain system.

The Rocky Mountains, regarded as forming the eastern mountain <sup>Rocky Moun-
tains.</sup> system of the Cordillera, are consequently interrupted in this part of their length. The range of which the northern extremity is here found has a length of over 1,000 miles. It extends uninterruptedly southward to the International Boundary, and is still further continued into Montana to about lat. 46° . The width of this persistent

mountain range probably averages throughout about fifty miles; and its main physical and geological features are almost identical in all parts of its length. Where the particular line of crumpling and upheaval of the earth's crust to which this range is due dies away at the Liard, another similar line begins, nearly in the same latitude, but about eighty miles farther to the east. The mountain range produced by this new line of disturbance extends northward nearly parallel to the general course of the Mackenzie to the Arctic Ocean.

South of the Liard the bare limestone ridges are ranged in parallel lines, and are surmounted by sharp zigzag knife-edges, or jagged serrated crests. The ridges have a general strike of N. 30° W. The spur of the mountains which crosses the river consists of greyish and moderately compact limestone. The beds are at first almost horizontal, but are soon thrown into almost vertical attitudes, and have the appearance of a sharp anticlinal. Several of the exposures were examined unsuccessfully for fossils, and the only specimens collected here consist of some fragments of corals which were found near at the mouth of Rivière des Vents, and resemble those occurring in the Intermediate limestone of the Bow River section. The limestones are exposed along the river for six miles, and are then covered with dark shales similar to those from which Triassic fossils were afterwards obtained. It is noteworthy that in the Liard section dark shales of Mesozoic age are found resting on both flanks of the mountains, and are not confined to the eastern slope, as is the case farther south.

East of the passage of the Rockies the mountains gradually recede from the river towards the south, and are replaced by high rounded and well wooded hills and ridges built of dark shales, numerous exposures of which occur all along the banks of the river. The shales undulate at all angles, and do not appear to have any predominating dip in towards the mountains such as characterizes them in other localities. They are interstratified in places with beds of quartzite, and are, so far as I could learn, completely unfossiliferous.

Since leaving Portage Brûlé the river has remained wonderfully smooth, and we had the pleasure of passing one night away from the roar of a rapid, and without the usual prospect of having the next morning either to run a rapid or make a portage. The river has here an average width of four hundred yards, and a steady current of about four miles and a half an hour. It is bordered in places by long gravel and sand beaches, and encloses occasionally wooded islands. Ten miles east of the gap, Trout River joins the Liard from the south. This is a

Rocks in
mountains.

Limestones
replaced by
shales.

Rounded hills
east of moun-
tains.

River smooth.

Trout River.

swift, clear mountain stream about a hundred and fifty feet wide, which seems to cut back into and drain the central ranges. Below Trout River the Liard bends abruptly to the north for some distance, and then, turning to the east continues on with an ever increasing current between banks which gradually become steeper and higher, until they develop into a wide cañon. We had been on the lookout for the Devil's Rapids ever since leaving the Rivière des Vents, and as the threatening appearance of river and valley indicated that we were approaching them at last, we dropped down cautiously along the right bank, watching carefully all the time for signs of the old portage. Threatening appearance of river.
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The river at this point makes a great bend to the north-east, all around which is a succession of rapids and cañons. At the elbow of the bend a large fall is reported. At the lower end of the bend, the Fall reported. river is reduced to a mere thread, as it is scarcely a hundred and fifty feet wide, and as fully a third of this is occupied by shore eddies, its bed must be eroded to an enormous depth. Immediately below the contracted part is a large eddy, and the river expands at once to over half a mile in width.

THE DEVIL'S PORTAGE TO HELL GATE.

The portage across the bend proved, greatly to our satisfaction, to be less than four miles in length instead of twelve, as we had been informed and expected. It is however very difficult, as it passes over a ridge fully a thousand feet high, on both sides of which the slopes are exceedingly steep. The old portage track was easily followed among the heavy timber for some distance after leaving the upper end, but going east it became gradually overgrown with brushwood, and at last disappeared and we were obliged to cut out a new one for ourselves. This track was cleared out by Mssrs McCullough and Thibert, in 1871 for the purpose of hauling their boat across, and it speaks somewhat favorably for the activity of forest growth in this region, that it should now be covered with shrubs and small trees several inches in diameter.

Abundance of moose. In crossing the portage we started several moose, and it may be mentioned here that the country we have been passing through and as far on as Hell Gate, is probably the best moose country in North America. Everywhere we landed, fresh tracks in abundance were observed. We killed one at the mouth of Rivière des Vents, and another farther down near Crow River, and could have shot a number of others if we had so desired. At the "Rapids of the Drowned" we scared three into the river, but these unfortunately attempted to swim the rapids and were drowned. They were found afterwards some distance below lodged in a drift pile. Their abundance is due to the fact that the country is practically uninhabited. After leaving the Little Cañon we saw no Indians nor any traces of them, such as old camps, abandoned canoes, old cuttings, &c., anywhere along the river. The country in question forms a kind of neutral ground between the Indians trading east and west of the mountains, and is also difficult of access on account of the danger in navigating the river. The absence of Indians and the consequent immunity from hunting enjoyed by the moose, since the abandonment of old Fort Halkett, has resulted in a great natural increase in their numbers. Besides, as they are persistently hunted in the adjoining country on either side of the mountains, by the bands of Indians trading at Fort Liard, and at the mouth of Dease river respectively, many of them must escape into this district as into "a city of refuge." The beaver are also abundant, and like the moose, appear to have thriven in the absence of their hereditary enemies. Grizzly bears were reported to be especially common on the Devil's Portage, but we did not meet with any.

Rig up canvas boat.

We spent altogether six days on the Devil's Portage crossing our outfit and framing a boat. We found that it would be impossible to cut out a track and haul our heavy wooden boat up the steep hills on the portage without wasting more time than we could well spare, and decided, somewhat reluctantly, to abandon it. To meet such an emergency I had provided myself, before leaving Ottawa, with a roll of stout canvas sewn up in the shape of a boat, and this we at once proceeded to put into shape. It was stretched on a stout plank hewn out of a small pine tree. Spruce poles, to which the canvas was firmly sewn, were used as gunwales, and willow withes for ribs, while slips to lay between the ribs and the canvas were easily cut. We painted the canvas with half a gallon of oil, which had been brought for the purpose, but this did not prevent it from leaking badly, and we were obliged to give it a second coat, made up of everything oleaginous which we still possessed. This mixture consisted of sperm candles, gun oil and bacon grease, stirred up with spruce gum, and

proved effective in keeping out the water. Our new boat was not well adapted for running heavy rapids, especially where sudden turns had to be made to avoid rocks, but was quite serviceable in ordinary water and on easy riffles, and was, besides, light and easily portaged.

Below the Devil's Portage for thirty or forty miles the river flows through what is called the Grand Cañon, but is more correctly a succession of short cañons, with expanded basins between filled with eddying currents. In low water the whole of this reach can be easily run in almost any kind of a boat, but in the season of high floods such as it was when we passed through, the water forcing its way through the throat-like contractions is thrown into a commotion too violent for any but the staunchest boats to stand. The cañon is reported to have been run in two hours, which would be at the rate of about eighteen miles an hour, an astonishing velocity, but the time was probably underestimated. It took us several days to get through, but we were obliged to make a number of short portages and one of over three miles in length.

We launched our canvas boat and commenced the descent of the Grand Cañon on the 16th July. I had previously explored the river for some distance and knew that we had nothing serious to encounter for several miles. The river is at first wide and encloses a number of islands. As we proceed the bordering banks close in, become higher and steeper, while the current runs with increasing impetuosity until, rounding a bend, it breaks into foam against a barrier of rocks which intercepts its course. We passed this by a small portage and then continued our headlong course down the river, but were soon stopped again by a succession of bad riffles. In the next couple of miles we ran through a number of wild places, the canvas boat riding the waves gallantly, but were forced to make one or two short portages and then entered a deep, gloomy defile, walled in by black vertical cliffs. The river here is, however, less boisterous and flows with a steadier current. Part way down the cañon a couple of small islets with steep, rocky banks divide the stream into several channels. These were soon left behind, and then hurrying through a second narrow pass we came out on a wider portion of the river. In the next twelve miles the river is generally wide and shallow and filled with gravel bars. The current is still swift, running at the rate of seven miles an hour, but the navigation is easy.

At the end of this reach it bends to the north, and striking violently against some sombre cliffs which line the left hand bank, is deflected again to the east with the formation of what are known as the "Rapids of the Drowned." Here, one of the most dangerous spots on the river

is formed by the water plunging with its whole force, over a ledge of rock which curves outwards and downwards from the left hand bank, into a boiling *chaudière* behind.

Name of rapid. The name of the rapid originated from the drowning at this point of a Hudson Bay clerk named Brown, and a boat load of voyageurs. As the story goes, Brown, disregarding the advice of his steersman, insisted on running close to the northern bank, and the canoe plunging into the hole mentioned above was drawn under.

We passed the rapid by letting our boat down cautiously with a rope to the *chaudière*, and then making a short portage. With a proper boat, however, no difficulty would be experienced in crossing the river above the rapid, and running down close to the right bank.

Below the "Rapid of the Drowned" is a long riffle, down which we ran at an exciting pace, and then the river is closed in by a hard sandstone bank, through a narrow gap in which it forces with difficulty a stormy passage. An examination of this convinced me of the impossibility of running it at the present high stage of the water with a boat such as we possessed, and also disclosed the unwelcome fact that a number of similar obstructions existed ahead. In the next four miles the river is closely cañoned in, five times, and falls over a number of riffles. Only some of these are dangerous, but we were forced to portage around the whole reach, owing to the steepness of the banks and the impossibility of getting down to the bottom of the valley, except at a few points. Three miles of rapid current followed, and then we reached Hell Gate, so named because it is the entrance from below, to the wild portion of the river we have been descending. At this point there is an abandoned channel on the left hand side, which is navigable in high water, and affords an easy passage through.

Hell Gate.

Rocks between Devil's Portage and Hell Gate.

From the Devil's Portage to Hell Gate the rocks noticed on the banks of the river consist mainly of shales, with bands of sandstone at intervals, and occasionally some limestone. Exposures of the latter occur at the east end of the Devil's Portage, where they are brought up by an anticlinal from below the shales. They are here greyish in colour, are moderately crystalline, and hold fragments of crinoids and other fossils, and evidently belong to the upper part of the Palaeozoic series of the mountains. This series was not observed farther east. The shales are usually rather hard and weather into high bold cliffs, which often border the river on either side for miles without a break. They are dark in colour, and as a rule are rather coarsely laminated, but vary greatly in this respect and also in their texture. The shales undulate at all angles, and are continuously exposed all the

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way down the cañon. They are interstratified with a hard greyish and yellowish sandstone, and a dark compact limestone. The sandstone occurs in bands, which form constrictions where they cross the river, and in the adjoining country rise into high hills and ridges. The limestones associated with the shales are usually impure and occur as a rule in thin shaly beds, but heavily bedded varieties were also observed at Hell Gate and at other places.

No fossils were obtained in descending the cañon until the "Rapids Triassic fossils, of the Drowned" were reached, where the following species, since described or determined by Mr. Whiteaves and referred by him to the Trias, were obtained.*

- Spiriferina borealis*, Whiteaves.
- Terebratula Liardensis*, "
- Monotis ovalis*, "
- Halobia (Daonella) Lommelli*, Wissman.
- Halobia occidentalis*, Whiteaves.
- Nutilus Liardensis*, "
- Popanoceras McConnelly*, "
- Trachyceras Canadense*, "

Some miles farther down at the lower end of the last cañon before coming to Hell Gate, a second fossil locality was discovered which yielded the following species.

- Terebratula Liardensis*, Whiteaves.
- Trigonodus ? productus*, "
- Margarita Triassica*, "
- Popanoceras McConnelly*, "

At Hell Gate three miles below the last, specimens were obtained of—

- Trachyceras Canadense*, Whiteaves.
- Terebratula Liardensis*, "

The localities from which Triassic fossils were obtained, extend along the river for ten miles, but it is highly probable that the rocks of this age have a much wider distribution than this and include the greater part of the barren shales above the "Rapids of the Drowned," as well as those below Hell Gate. It will require, however, more time than could be spared on a rapid reconnaissance, to separate precisely the shales which cap the Palaeozoic from those of the Trias,

* Contributions to Canadian Palaeontology, Vol. I, Part II, pages 127-149.

and the latter from the Cretaceous. The three terranes are closely allied lithologically and will have to be defined largely from fossil evidence.

HELL GATE TO FORT LIARD.

River below
Hell Gate.

Escaping from Hell Gate cañon, the river dilates as usual and is bordered by large eddies. Below these, it runs swiftly around a large island, and then enters a cañon-like reach of the river about a mile long. The stream here is narrowed down to about a hundred and fifty yards in width, and flows easily between vertical banks three hundred feet high. This cañon proved to be the last on the river, and from this point on the river has an uninterrupted flow, and presents no obstacles to navigation until near its mouth. Five miles below the cañon the undulations in the shales and associated sandstones and limestones cease, and at the same time the ridgy and hilly foot-hill district we have been passing through is replaced by a region of high irregular plateaus.

Foot-hills.

The foot-hills along the Liard have a width of 38 miles, and are characterized by a much greater irregularity in altitude than is usually the case. South of the Devil's Portage, Mount Prudence, a steep-sided, reddish looking mountain, rises abruptly from a surrounding of round topped hills to an estimated height of over 4,000 feet. Going east from Mount Prudence, lower elevations prevail until near the "Rapids of the Drowned" where the ridges again commence to increase in elevation, and in a few miles culminate in peaks over 4,000 feet high. Still going east they gradually diminish in importance and at last die away and are replaced by flat-topped plateaus. This region with the exception of the higher peaks, is everywhere densely forested, chiefly with the white spruce, the banksian pine and the aspen.

River east of
foot-hills.

After leaving the foot-hill country the river runs in a general direction of N. 30° E. for thirty miles. In this reach it has a steady current of about four miles and a half an hour, and varies in width from five hundred yards to over a mile. In the wider portions the river is usually divided into several channels by islands and bars. The valley is narrow and trough-like, with steep sides rising up in places to a height of fully a thousand feet. The bottoms are usually small, and are here chiefly wooded by members of the poplar family. Some important tributaries are received by the Liard in this portion of its course, among which is Crow River, which joins it from the north after entering the plateau country, and Toad River, which comes in from the south through a deep gloomy valley four miles farther down. Two miles below Toad River, on the opposite side, is situated Toad

River post, which was abandoned when the post on the Nelson was established. The buildings are still standing.

The geology of the plateau belt is exceedingly simple. The banks of the valley are usually scarped, and show everywhere extensive sections of flat-lying shales. These shales are dark in colour, are soft and finely laminated, and are interstratified with small beds of sandstone and ironstone, and layers of ironstone nodules. They are of Cretaceous age, but their mode of junction with the Triassic shales of the foot-hills was not clearly ascertained. Some fossils were collected from this formation about four miles below Toad River, among which are specimens of *Placenticeras Perezianum*, a species of *Camptonectes*, and fragments of an *Inoceramus*. Towards the eastern part of the plateau belt the shales along the river are overlain by massive beds of soft sandstone and conglomerate, which form a steep escarpment running parallel with the river.

At the end of the northerly reach just described, the river, here over a mile wide and filled with islands, bends suddenly at right angles to its former course, and after passing through a narrow gap, enters a much lower country. The steep scarped banks of the plateau district disappear, and are replaced by gently inclined hillsides covered with forest, while the river spreads out and flows for some miles in a multitude of channels through a bewildering maze of islands.

The eastern edge of the plateau district faces eastward with a steep slope, and has a height of over a thousand feet. It runs nearly due north and south and forms an important feature in the general topography of the country. Where it crosses the river it shows exposures of soft conglomerates dipping lightly in an easterly direction. East of this escarpment Beaver River joins the Liard from the north. This is reported to be a fair sized stream and to be navigable for canoes for a long distance. It empties into the Liard behind a group of islands and we passed it without seeing it. Near its mouth we saw Indians for the first time since leaving the mouth of the Dease. They belonged to Ft. Liard, and were on their way up the Beaver to hunt. We endeavored to buy some meat from them, but found that they were totally unacquainted with the use of money, and as we were not supplied with trading goods, or, in fact, with anything except what we wore, it was found impossible to strike a bargain.

East of the Beaver the Liard runs in a south-easterly direction for a few miles and makes a couple of sharp bends before joining the Nelson. In the first of these bends we met a crew of Hudson Bay voyageurs in charge of W. Lépine, who were endeavouring to make their way up the river to the mouth of the Dease. Lépine had been employed on

the river as a guide, in the old days when goods were taken by this route to the Yukon, and was well acquainted with it. He brought news of a scarcity of provisions in the Mackenzie River District, and this decided me to send my two men back up the river with him, and to depend on the services of natives for canoe-men in the future. Lépine had become disheartened by the continued high water and the difficulties of upstream navigation, and when we met him talked of returning, but we induced him to persevere. A small spruce bark canoe which an Indian and his wife built in an afternoon, in addition to the large birch canoe which he already possessed, furnished sufficient accommodation for his increased party, and on the 28th July, after a day's delay, he proceeded up the river. I afterwards learned that with the exception of one upset, caused by the unskillfulness of Trépanier, one of my men, the journey was successfully accomplished and Dease River reached in safety.

After separating from Lépine I continued down the river to Fort Liard in the canvas boat, at first in company with an Indian, but for the greater part of the distance entirely alone. After starting we rounded a large bend and then continued in a northerly direction to the mouth of the Nelson, or east branch of the Liard.

Nelson River. Nothing has been published concerning the Nelson, but it is reported to be a somewhat sluggish river of about one hundred and fifty or two hundred yards in width. A hundred miles above its mouth is situated Ft. Nelson, a Hudson Bay trading post. Above the Fort the river divides into two branches, one of which, named Buffalo River, turns west to the mountains, while the other continues on and interlocks with tributaries of Hay River.

* In 1872-73 a party of miners crossed from Peace River to the Liard by way of the Nelson on a prospecting trip. They descended Peace River to Half-Way River, so called because it is half way between Rocky Mountain Portage and Fort St. John, and ascended the latter partly in canoes and partly on the ice for a hundred miles. They then made a portage of twenty-five miles, and reached the Nelson, down which they sledded for sixty miles, and then built boats and came the rest of the way by water. They only mention one portage of half a mile, but describe the river as flowing for a long distance above Fort Nelson, between lofty banks of sandstone and shale. Colours of gold were obtained on the Liard at the mouth of the Nelson.

Fort Nelson. At Fort Nelson some farming is annually done, and potatoes and

* Extracted from letter by Fred. W. Harte.

other vegetables are grown without difficulty. The surrounding country is everywhere well forested, and is reported to produce a better grade of timber than any other part of the Mackenzie District.

Below the Nelson the Liard has a general northerly direction for Liard below the Nelson, thirty miles, and then, bending more to the east, follows a N.E. course as far as Fort Liard, fifteen miles farther down, where I arrived on July 29th. In this reach it has undulating shore lines, but is generally wide and filled with sandbars and wooded islands. It is bordered in many places with wide alluvial flats, covered with tall, straight cottonwood, and large spruce, and canoe birch. Its valley is wide and shallow and lined with gently sloping, spruce clad banks. On some of the flats the Indians have built houses, and fenced in small plots for farming purposes, for which the greater part of this section of the district seems well adapted. We passed one small Indian farm about thirteen Indian farms, miles below the mouth of the Nelson, and another one at the mouth of Fishing Creek, a few miles above Fort Liard, while others were noticed in the lower part of the river.

The two principal tributaries of the Liard between the Nelson and Tributaries of Liard. Fort Liard are Rivière la Biche and Black River. The former enters it from the N.W., about twenty miles below the Nelson, and the latter from the S.E. at Fort Liard. Black River is the outlet of Lake Bis-tchô, a large lake situated about 120 miles S.S.W. of Fort Providence, and is reported to be navigable with difficulty throughout its entire course in high water. It will afford, with the Nelson and Hay rivers, a ready means of entering and exploring the vast block of unknown country lying between the Liard and Peace River, the Mackenzie and the Rocky Mountains.

Since leaving the plateau district the rock exposures observed along Rocks east of plateau district. the river have been few and small, and consist of dark shales, alternating with sandy shales and sandstone, all of Cretaceous age. Twelve miles below the Nelson an exposure of sandy shales and sandstone yielded, an *Ostrea* like *Ostrea subtrigonalis*, and at the mouth of Black River, near Fort Liard, in a hard, crumbly shale, specimens of an *Inoceramus* were obtained, while the surface of the shale in some places is covered with well marked impressions of gigantic palm leaves, probably belonging to the genus *Sabal*, which occurs in Vancouver Island in rocks of a similar age.

The quaternary deposits in this part of the river are represented by Quaternary deposits. stratified sands and gravels, immediately overlying the shales, and by gneissic erratics, which are distributed everywhere over the surface of the country, and in some places, as at the mouth of Black River, are present in great profusion. The western limit of the eastern drift

Eastern drift. along the Liard, judging from the river section, appears to be nearly coincident with the eastern edge of the plateau district, although gneissic fragments were found in the mountains opposite Fort Liard at a somewhat higher elevation.

Rocky Mountains. Thirty miles below the Nelson, the Liard approaches and for the next seventy-five miles hugs closely, a chain of mountains which may be considered as a northern division of the Rocky Mountain system, and as the complement of the chain around the northern end of which the Liard passes west of the Devils Portage. The mountains are not fringed with a belt of foot-hills, such as usually accompany them in other places, but rise abruptly from an almost level plain, and attain at once their full height of about 4,000 feet. The folds and fracture to which the mountains are due also seem to die away with startling rapidity. The Liard for fifteen miles above Black River, cuts at a distance of two to five miles directly across the strike of the ranges, and yet the beds along its valley wherever seen are practically undisturbed. While waiting at Fort Liard I climbed one of the ranges to a height of 3,000 feet, but obtained little geological information. The rocks were only exposed in a few places, and where seen consisted of westerly dipping unfossiliferous chert and cherty limestone. Gneissic fragments apparently belonging to the eastern drift were found up to a height of over 1,500 feet. I obtained, however, an extensive view from the summit, over the plains to the eastward.

Climb range. The country in that direction rises gradually from the river in easy undulations, and appears to culminate at a distance of twenty-five or thirty miles in a low plateau through which Black River has cut a wide gap. A dense forest relieved in places by gleaming lakes and light green marshes stretches to the horizon. To the north and north-west the eye is met by a succession of bare topped and nearly parallel limestone ridges striking about N. 20° W. and reaching elevations of from 4,000 to 5,000 feet.

View from top of mountain. Fort Liard is at present the only fort on the Liard below the mouth of the Dease, and is resorted to for trading purposes by about two hundred Indians; most of whom are known as Nahanni or Mountain Indians. Under this term are included a number of tribal divisions of the Tinneh family, but the names of these I was unable to obtain. They are reported to be fast dying off. The fort is situated on a fertile flat, part of which has been cultivated for years with unfailing success. Wheat and barley are grown here year after year, while potatoes, cabbages, turnips and other vegetables are raised without the least difficulty. At the time of my visit, 1st August, all the crops were well advanced and in good condition; the barley was just turning colour, and the potatoes were almost large enough to eat. There is no reason, either

Agricultural resources.

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climatic or otherwise, why the whole country bordering the Liard, from Beaver River to near its mouth, should not, when needed, support an agricultural community.

FORT LIARD TO FORT SIMPSON.

I was delayed several days at Fort Liard before I could engage an Indian to accompany me down the river, but having at last succeeded, and also having exchanged my canvas boat for a bark canoe, I resumed my journey on the 5th August.

From Fort Liard the river has a north-easterly course for five miles, River below
Fort Liard. and then bending to the N.N.W., runs for over twenty miles nearly parallel to the easternmost range of the mountains, after which, while still preserving the same general direction, it makes a couple of great bends to the east before joining the Nahanni River at the foot of the Nahanni Butte. It has in this reach a general width of four to five hundred yards, and a current of about four miles and a half an hour. Islands and bars are of constant occurrence, and divide the river in many places into numerous channels. The valley depression for some distance below the fort is insignificant in size, and farther down disappears altogether, and the river undulates through a low, level plain, elevated only a few feet above its surface. As in the upper part of the river, the trees observed consisted of white spruce, aspen and cottonwood, with some banksian pine and canoe birch, and an undergrowth of willows and alders.

Four miles below Fort Liard is a cut bank showing Quaternary Rocks below
Ft. Liard. sands and gravels, while three miles farther down the same sands are underlain by sandy shales and sandstone, evidently belonging to the Black River *Inocerami* bearing series of shales and sandstone. This was the last Cretaceous exposure noticed in descending the river. In the next nine miles no rocks were observed, and then a small section of limestone shows that we have passed over the junction between the Cretaceous, and the Devono-Carboniferous. The concealment of the beds along this part of the river made it impossible to decide from the Liard section alone whether the Triassic beds which underlie the Cretaceous on the western side of the Cretaceous basin, underlie them also on the eastern side, or are overlapped by them. It is probable, however, that the latter is the case. A second outcrop of limestone occurs eight miles below the one just noted. The beds are here inclined at a low angle, and are fossiliferous. From the specimens collected, Mr. Whiteaves has identified the following forms: A *Streptorhynchus* of the type of *S. umbraculum*; two ribbed species of *Spirifera*, one of which

is very like *S. centronota*, Winchell; a smooth *Spirifera* of the *Martinia* section, probably identical with *S. setigera*, Hall, but closely related to *S. fimbriata*, Conrad; *Athyris subquadrata*, Hall; a new species of *Platyceras*; and *Proetus peroccidens*, Hall & Whitfield. The general facies of this fauna seems to indicate a horizon intermediate between the Devonian and Carboniferous, and probably equivalent to the Waverly group. Continuing down the river stratified sands were observed at the elbows of most of the bends, but the limestone is not again exposed until the Nahanni Butte is reached.

Nahanni Butte. The Nahanni Butte, called also Mount McPherson, after the gentleman who first ascended it, stands at the confluence of the Nahanni River with the Liard, and has been carved out of the twisted end of the easternmost range of the Rockies. It is easily reached from the river, and on this account I determined to spend part of a day in climbing it. I took up a small aneroid barometer, which gave the height as 3965 feet. From the summit much the same character of country was

View from
summit of
Nahanni Butte.

displayed as that previously seen from the ridge opposite Fort Liard. To the S. and S.E. a wooded plain dotted with lakes and marshes, and, with the exception of three small buttes which formed a miniature mountain range almost at our feet, without conspicuous elevations, stretches as far as the eye can see, while in an opposite direction the prospect showed range after range of bare and rugged limestone peaks, among which the Nahanni River pursued a tortuous course until lost in the distance. The ranges here, while preserving a general parallelism, are more than usually irregular in this respect, and in some cases follow a very zigzag course. The general strike is nearly due north and the general dip of the beds westerly. A group of high peaks, which bore almost west, were observed to be partly covered with snow, and were estimated to rise to an elevation of between five and six thousand feet.

Nahanni Butte section. In the Nahanni Butte three rock series are clearly defined. In the lower part is a great thickness, probably a couple of thousand feet, of coarse grained magnesian limestones. These limestones are heavily bedded and often show the striped and cavernous appearance so characteristic of the more massive varieties of the Castle Mountain group, to which they undoubtedly belong. Copper stains were noted in a number of places, but no specimens indicating deposits of economic value were obtained. The limestones are overlain by several hundred feet of black, finely fissile shales, which occupy the same relative position as the Graptolitic shales of the Kicking Horse Pass, but are not fossiliferous. Above the shales and forming the top of the mountain comes a series of light yellowish and greyish magnesian and ordinary limestones. These limestones yielded some imperfect and

scarcely determinable fossils, among which is a coral which shows the external characters of the Carboniferous genus *Stylaxis*, but the internal structure has not been preserved. A specimen of limestone from this series collected by Mr. McPherson and shown to Sir J. Richardson, is described by the latter as being similar to that which outcrops in the "Rock by the River's Side" on the Mackenzie. This would place it in the Devonian. A salt spring, with a basin fifteen feet in diameter, is reported by Sir J. Richardson on the authority of Mr. McPherson, as existing on the top of the mountain, but this I did not succeed in finding. A neighbouring mountain, however, showed a white patch on its steep side which is plainly due to the deposits of a mineral spring of some kind, and may be the one referred to.

From the Nahanni Butte and River the Liard bends more to the east, and for the next sixty or seventy miles follows a general east north-easterly course. In the first section, extending to the "Grand Reach," a distance of twenty-five miles, it is wide and somewhat tortuous and encloses several large islands. The valley is insignificant in size, and where cut into at the bends of the river, shows small sections of stratified sands only. The general features of the country here and for some distance above the Nahanni River, seem to show that the river along this part of its course flows through a lake basin which formerly existed at the foot of the mountains, but is now silted up. It is worth noting that the Mackenzie passes for some distance through the same style of depressed alluvial country when approaching the northerly extension of the same range sixty miles below Ft. Simpson, and it is just possible that the depression follows the base of the chain throughout.

The Long Reach is a beautiful stretch of gently flowing water of something over fifteen miles in length, and has an average width of fully a thousand yards. It is nearly straight, and a view down it discloses a long vista of smooth, glassy water which extends to the horizon, and is bordered by a succession of low wooded points which stretch out one behind the other until they fade away in the distance. Its valley is shallow and rises from the water's edge. At the lower end of this reach there is a decided rise in the general elevation of the country, which is at once made evident by the increased depth of the valley, while at the same time the river becomes narrower and its current swifter. The sand bars are replaced by shingle beaches, and for the first time the banks show sections of undoubted boulder clay. A few miles farther down, the river, now enclosed on both sides by low cut banks, makes a short bend to the east, at the elbow of which is an island with steep shale banks. In the next twenty-five miles the river

River below Nahanni Butte.

First appearance of boulder-clay.

is bordered by steep scarped banks from two to four hundred feet in height, and has the appearance of a wide cañon. The current in this reach is everywhere exceedingly swift, and for nearly ten miles breaks over a succession of strong riffles. These are easily run in a small boat by keeping close to the right bank, but will form rather a serious obstacle to the navigation of the river by steamboats. It is possible, however, that steamers may be taken up by lining, and once above them, the river affords easy navigation up the main branch as far as Hell Gate and up the Nelson, except at low water, as far as the forks.

*Rock sections
in valley.*

The banks of the valley all along this reach are bare and afford continuous sections of shales, limestones and calcareous sandstones lying in a nearly horizontal position. The shales are greenish in colour, are soft and alternate above with the limestones, which form the top of the section. The limestones are greyish, or light yellowish in colour, are moderately crystalline, and are often impure and pass into a species of calcareous sandstone. In this condition they often show ripple marks, worm burrows, and other evidences of a littoral origin. Fossils were found in a number of places, but are usually in a poor state of preservation, and the only forms which Mr. Whiteaves has identified so far are *Atrypa reticularis*, and two species of *Orthis*.

*Devonian
uplift.*

The Devonian uplift which crosses the Liard here extends far to the southward, and is doubtless the cause of the falls and heavy rapids which occur along the same line, on Trout River, Beaver River, Hay River, Buffalo River, and in fact on all the streams coming from the west and emptying into the Mackenzie or Great Slave Lake. It is possible, also, that the Vermilion Falls on Peace River may be due to the same cause. The Devonian in all this region has an upper division of hard limestone and a lower one of soft shales, an arrangement peculiarly favourable for the production of falls.

*Mouth of
Liard.*

After passing the rapids the river continues to run with great velocity for some miles and then the current gradually moderates, and at the same time the valley loses its cañon character, and for some miles cut banks are only occasionally seen. Approaching the Mackenzie the Liard turns away to the north, and gradually enlarging itself, pours its tribute into the former, through an embouchure of over a mile in width.

In the lower part of the river the Devonian shales and limestones disappear beneath a covering of boulder clay and other glacial deposits, sections of which appear all along. They crop out again on the right bank of the Mackenzie, opposite the mouth of the Liard, but at this point they are not fossiliferous.

SLAVE RIVER.

I finished the traverse of the Liard and reached Fort Simpson on the ^{Fort Simpson.} 9th August. This post is situated on an island at the junction of the Liard and the Mackenzie, and is the headquarters of the Mackenzie district. I was fortunate enough to catch here, after a delay of a few days, the Hudson Bay Co.'s steamer Wrigley, which was on its way up from Peel River, and proceeded on it to Fort Smith, on Slave River. On the way up arrangements were made with Mr. Cummings and Mr. Reid, of the Hudson's Bay Co., subject to the approval of Mr. Camsell ^{Make arrangements to winter at Ft. Providence.} the chief factor of the district, who was absent, to winter with Mr. Reid at Fort Providence, and I was thus left at liberty to continue work as long as the season permitted. After arriving at Fort Smith I made a trip across the portage, and then embarking in a bark canoe with a couple of Indians, started down Slave River. This river has been used by the fur traders for over a century, and the Mackenzie for nearly as long, and as both have been visited by numerous celebrated travellers, to whose narratives I will be obliged to make frequent references, it will be necessary here, before proceeding with a description of the river, to give a brief account of the progress of exploration.

The honour of discovering Great Slave Lake and River belongs to ^{History of exploration.} that persevering traveller, Samuel Hearne, who reached them on his return from his third and successful journey to the mouth of the Coppermine. Hearne arrived at Great Slave Lake on the 24th of December, 1771, and crossing it in a leisurely manner, reached Slave River on the 16th January, 1772. He continued up the River until the 27th, and then after having travelled upwards of forty miles, he "left it at that part where it begins to trend due south," and struck off to the eastward. Hearne calls the lake Athapuseow Lake, and describes it as being one hundred and twenty leagues long from east to west, and twenty wide from north to south. He was particularly pleased at the change from the "jumble of rocks and hills," which cover the country north of the lake, to the "fine level country in which there was not a hill to be seen or a stone to be found," which he met on the southern side. It is interesting to note that at the time of his visit this region swarmed with buffalo.

Hearne was followed, in 1789, by Sir Alexander Mackenzie, but the ^{Mackenzie's voyage.} fur traders had before this extended their operations as far as Slave Lake, as Mackenzie states that Messrs. Grant and Leroux had erected houses at the mouth of Slave River in 1785.* Mackenzie left Fort Chipewyan on June 3rd, and reached Slave Lake on the 9th, but was

* Page 8 Mackenzie's Voyage through North America.

delayed on the lake by ice and did not succeed in entering the mouth of the river into which the lake emptied until the 29th. He then followed the river, since called after himself, until it debouched into the polar sea. The object of Mackenzie's voyage was to further the interests of the fur trade by discovering a passage to the Pacific, an object which he afterwards attained by crossing the mountains by the Peace River Pass.

*Franklin's
first voyage.*

In 1820 Captain, afterwards Sir John Franklin, descended Slave River, and crossing Slave Lake to Fort Providence, which was then situated on a northern arm of the lake, started on his memorable voyage down the Coppermine to the shores of the Arctic Sea. He was accompanied by Dr. Richardson and Mr. Back, both of whom were subsequently knighted as rewards for their success in arctic exploration.

*Franklin's
second voyage.*

In 1825 Franklin, again associated with Dr. Richardson and Lieutenant Back, descended Slave River and the Mackenzie to the sea, and in the succeeding summer explored all the Arctic coast between Return Reef and the mouth of the Coppermine. In 1833 Captain Back was placed

*Back's
expedition.*

in charge of an expedition which was sent out to search for Sir John Ross. On this occasion he wintered at the east end of Great Slave Lake, and in 1834 explored Great Fish or Back's River from its source in Sussex Lake to the sea. Back was followed, in 1837, by Thomas Simpson, probably one of the most energetic of the many famous travellers who have worked along the confines of the frozen ocean. Simpson (Dease and Simpson expedition) was sent by the Hudson's Bay Co. to explore the coast between Point Barrow and Return Reef, and between Point Turnagain and the mouth of Great Slave River. This difficult service was successfully accomplished in three seasons.

*Richardson's
exploration.*

In 1848 Sir John Richardson again descended the Mackenzie, this time in search of his former chief, and for the second time navigated the sterile coast stretching from the Mackenzie to the Coppermine. He was assisted in this expedition by Dr. Rae. Richardson in his various journeys, spent altogether about seven years in the north, and has given us by far the best and most trustworthy account of the ethnology, natural history and geology of the boreal regions.

*Pullen ascends
Mackenzie:*

Richardson was followed by Captain Pullen, who ascended the Mackenzie in 1849-51, after traversing the coast between Icy Cape and the mouth of the Mackenzie, previously delineated by Beechy, Elson, Simpson and Franklin.

In addition to the explorers named, M. L'Abbé Petitot, a Roman Other explorers Catholic missionary, spent a number of years travelling in the region adjoining the Mackenzie, and has published a map and a series of

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papers describing the geology and ethnology of the district.* Major Kennicott also passed a couple of years on the Mackenzie collecting natural history specimens for the Smithsonian Institute. He also made a collection of fossils, which formed the basis of an interesting paper published by F. B. Meek in the proceedings of the *Chicago Academy of Sciences*, 1868, on the geology and palaeontology of the valley of the Mackenzie. Professor Meek also refers to fossils collected by Messrs. R. W. McFarlane and B. D. Ross, of the Hudson's Bay Co., and by the Rev. Mr. Kirby, of the Church Missionary Society.

The geological notes of the various Arctic travellers above mentioned have been collected together by Dr. G. M. Dawson, and published as part R. of the Annual Report of the Geological Survey for 1886.

Slave River flows from Athabasca Lake to Great Slave Lake, and Slave River, performs the important function of uniting the waters of the Peace and Athabasca rivers with the Mackenzie. It runs a little west of north, and has a total length of about 290 miles. For about a hundred miles below Lake Athabasca it is easily navigable, but its course is then interrupted by a series of short rapids, which have altogether a length of fourteen miles, and form the only break in the navigation of the waters of the Mackenzie between Fort McMurray on the Athabasca and the Arctic ocean, a distance of about 1,630 miles. A cart trail has been cut out by the Hudson's Bay Co. around these rapids, and a number of horses and oxen are employed during the season in transporting the freight brought down by the Athabasca steamer across the portage to Fort Smith, where it is placed on board the Mackenzie River steamboat and distributed among the various posts down the river.

The rapids are caused by a gneissic spur from the Laurentian district to the east, which crosses the river here, and must extend a considerable distance in a westerly direction. At the lower end of the rapids an exposure in the bed of the river was found to consist of coarse grained hornblende granitoid gneiss. These rocks have an imperfect foliation, chiefly marked by a roughly linear arrangement of the hornblende granules. They are polished and striated by the action of the river ice. Another exposure at the south end of the portage showed light colored and well foliated gneisses striking in a westerly direction.

The country in the vicinity of the rapids is mostly level, and is covered with white spruce, banksian pine, the rough and smooth barked poplars and various species of willow and alder. The Mackenzie River steamer was built here in the winter of 1887 and the timber used in construction was all obtained from the surrounding forest. The soil

* See Bulletin de la Société de Géographie, Paris 1875.

Soil and
agriculture.

is often sandy, but good crops of potatoes and other garden vegetables are grown at Fort Smith, and also by the Indians on the east side of the river. A ridge of high hills is shown in most maps crossing Slave River at the rapids and running in an easterly direction, but these have no existence in reality.

Bell's Rock.

Slave River below the rapids is extremely uninteresting geologically, as the older rocks are nearly everywhere concealed under a heavy alluvial covering. The deposit of post glacial stratified sands is so continuous, and spreads so far on both sides of the river as to lead to the supposition that it was laid down in an ancient arm of Slave Lake, which extended to the south along the line of junction of the Laurentian and Palaeozoic, and corresponded in a general way to the arm of this lake, which now stretches to the north along the same geological line. The banks of the river, which at first are about one hundred feet high, and in places are broken up into terraces, become lower as we descend the river. Seven miles below Fort Smith, on the left hand bank, is Bell's Rock, a square, massive looking cliff, composed of light yellowish brecciated limestone. The bedding of this rock is indistinct, and it yielded no fossils or other evidence of age. It enjoys the distinction of being the only exposure observed between the rapids and Slave Lake. A couple of miles below Bell's Rock we passed on the right the fishery at Pointe de Gravois, and a few miles farther on reached the mouth of Salt River, which comes in from the left. Slave River in the distance traversed has an average width of nearly half a mile, and is characterized by numerous sandy beaches and bars and by occasional wooded islands. It has a current in low water of two miles and a half an hour.

Character of
Slave River.

At the mouth of Salt River is a house belonging to one of the numerous Beaulieu family, the members of which have been so frequently noticed by arctic explorers. I found the present representative of the name living in a lodge with his numerous progeny, and supporting himself by catching Ineonnu (*Stenodus Mackenzii*). This fish, as pointed out by Richardson, finds its southern limit at the foot of Slave River Rapids, which are too violent for it to ascend, and below which, consequently they collect at certain seasons in great numbers. Beaulieu, in addition to his fishing, claims the proprietorship of the salt springs on Salt River, but his laudable attempt to derive a revenue from this source has been foiled by the discovery by Mr. Scott Simpson, of the Hudson's Bay Company, of other salt deposits farther up the river.

Ascent of Salt
River.

I ascended Salt River on August 26th as far as the springs. This stream is about thirty or forty yards in width, and winds in an exasperating manner through a flat wooded plain. Its water is

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distinctly brackish and unfit for use even at its mouth, and increases in salinity as it is ascended. It has scarcely any valley, and its low banks, where uncovered, afford sections of the same clays and sands as seen on Slave River, and evidence the wide distribution of this alluvial deposit. Near the springs the river forks, and while one branch turns off to the south the other pursues a winding way through the salt plains. These plains are four or five miles in width, and are bounded to the west and north by swelling ridges covered with spruce and aspens, the leaves of which at this date, 26th August, were already turning yellow. The plains are well grassed, and in former days were the favourite feeding grounds of the buffalo, and even at the present time stray survivors of this fast disappearing animal are occasionally killed here, although we were not so fortunate as to see any. The springs have been visited and described by both Back and Richardson. They are situated near the base of the ridge mentioned above, are three or four in number, and are surrounded for some hundreds of yards by a salt-sprinkled and desolate looking clay flat, through which numerous briny streamlets make their way to the river. The springs are enclosed by small evaporating basins, the largest of which is about fifteen feet in diameter, and is crusted with a remarkably pure deposit of sodic chloride. The salt obtained here is of excellent quality, and has been used in the Mackenzie River district for many years.

The ridge behind the springs is composed of light yellowish limestone, and holds, according to Richardson, several beds of greyish compact gypsum. Some brachiopods were collected here, but are too imperfect for identification.

We descended Salt River on the 27th August, and resumed our course down Slave River. This stream presents few features of interest. Its average width is about half a mile, but it frequently spreads out around islands to twice this size. Sandy beaches, bars and islands occur all along its course, and are constantly shifting their positions, and being built up and destroyed by the spring freshets. The birth and growth of one of these islands is thus described by Richardson.* "A great quantity of large drift timber is brought down by Peace River; and as the trees retain their roots, which are often loaded with earth and stones, they readily sink, especially when water-soaked, and accumulating in the eddies form shoals, which ultimately augment into islands. A thicket of small willows covers the new formed island as soon as it appears above water, and these fibrous roots serve to bind the whole together."

* First journey of Franklin, page 518.

Such an island by diverting the course of the stream may produce currents, which will result in its own destruction, or, as often happens, it will travel slowly down stream; the slow erosion at its head being counterbalanced by the accretions received in the eddy at its lower end. Beds of drift timber in varying stages of decomposition alternate with the clays and sands in many of the islands, and in some cases constitute a considerable proportion of the whole material.

Slave River
below Salt
River.

Wooded plains.

Below Salt River, Slave River runs in a south-westerly course for fifteen miles, and then makes a great bend to the west called Le Grand Détour. This bend is nearly fifteen miles around, but can be avoided by a short portage of a few hundred paces across its narrow neck. Twelve miles below Le Grand Détour is Pointe Brûlée, the extremity of a blunt easterly bend, and some thirty miles farther down is Point Ennuyeux, around which we have to paddle nearly ten miles in order to advance half a mile on our course. On both sides of the river are level plains, which extend without any evident elevation as far as the eye can reach, and support extensive forests of white spruce and banksian pine mingled with larch and rough and smooth barked poplar. The spruce frequently attains a diameter of eighteen inches, and affords excellent timber. A few miles west of Slave River, on Little Buffalo River, wide grassy plains, destitute of trees, and resembling in appearance the great prairies to the south, are stated to exist. This style of country finds its northern limit here, as it was not observed anywhere north of Great Slave Lake.

After rounding Point Ennuyeux we passed on the right a point covered with massive boulders and limestone fragments, and then entered a small *chenal* behind Big Island, a narrow spruce-covered island about six miles long. From Big Island the river runs in a north-westerly direction for thirty miles to Rivière à Jean, one of its outlets into Slave Lake. From this point the western channel, after rounding Point Seul, follows an easterly course to the lake, which it enters by a number of channels separated by low marshy islands, formed from the sediment brought down by the river.

Slave River brings down an enormous amount very year, and has pushed its delta far out into the est part of which it threatens to inflict a similar fate that wh has already overtaken the southern arm.

From the mouth of Slave River we turned to the west, and passing through a narrow channel, inside of a couple of islands, reached and crossed a shallow bay, about a mile wide, and then turning to the south between Mission Island and the mainland came suddenly in sight of Fort Resolution, where we arrived on August 31st.

GREAT SLAVE LAKE AND SURROUNDING COUNTRY.

Great Slave Lake, so far as known, has a superficial area, including Great Slave Islands, of about 10,400 square miles, and ranks fifth among the great lakes of the continent.* No complete survey of its shores, however, has yet been made, and our knowledge of its geography is still confined to the disconnected explorations of Hearne, Mackenzie, Franklin, Back and Petitot. These give the lake a total length from east to west of about 288 miles. Its width is variable, and in one place exceeds sixty miles. It is situated along the western margin of the Archean axis, and had originally the form of a great cross with one arm penetrating the crystalline schists, while two others stretched north and south along the junction of these with the newer sedimentaries, and the fourth extended itself over the flat-lying Devonian to the west. The southern arm, as stated before, has been silted up by Slave River.

Size of Great Slave Lake.

The eastern or archean portion of the lake has an irregular outline, ^{Eastern portion of lake.} and is dotted with rocky islands. It is reported to be much deeper than the western part, and its water is exceedingly clear and limpid. The eastern part of this arm is divided, according to Back, by Rabbit Point (Gah-houn-tchella) and Owl Island (Peth-the-nueh) into two deep bays, of which the northern is called McLeod's Bay and the southern Christie's Bay. The latter is still very imperfectly known, and principally from Indian report. It is stated by Petitot to receive five streams† "les rivières du Rocher, des Seins, du Loup, de la Terre-Blanche et de la Poudrerie," none of which are of any considerable size. North of Christie's Bay is Owl Island, which is stated by Back to be fifty-four geographical miles in length, and is described as being an accumulation of trap mountains,‡ "and to exhibit long lines of mural precipices resting one upon another, and capped by even and round eminences, thinly clad with meagre pines." This island increases gradually in height towards the east.

North of Owl Island is a narrow sheet of water filled with bold and picturesque islands, and terminating to the east in McLeod's Bay. Into this bay Hoar Frost River precipitates itself over a precipice sixty feet in height, and the Ah-hel-dessa, the outlet of Artillery Lake, in a quieter manner.

The country north and east of the eastern part of this lake is described by Back as covered with bare roundbacked hills and ridges which

* It is exceeded in size by Superior (31,500), Huron (23,800), Michigan (22,300), and Great Bear (11,400).

† Bulletin de la Société de Géographie, Paris, 1875, page 143.

‡ Fitton's Appendix to Back's Journal, page 545.

rise gradually from the water's edge to a height of ten to twelve hundred feet, and are separated by sparsely-wooded and moss-covered valleys. This part of the lake approaches within twenty miles of the "Barren Lands," as the pines are said by Back to disappear along Artillery Lake in Lat. $63^{\circ} 15' N.$

West of Owl Island the lake contracts, and is filled with an archipelago of small islands, which extend to the eastern edge of the crystalline rocks near the mouth of Slave River.

Northern arm of lake.

The northern arm is situated nearly opposite the mouth of Slave River, and is narrow and filled with islands. At its upper end it contracts, and opens out again under the name of Lake Brochet, which communicates in turn by a short river with Marten Lake. Yellow Knife River, at the mouth of which old Fort Providence was situated, and which Franklin ascended on his way to the Coppermine, enters this arm from the east.

Eastern arm of lake.

The eastern arm of Great Slave Lake rests on the flat-lying Devonian limestones, and is wider, and presents a greater expanse of water, unbroken by islands, than either of the other divisions. Its southern shore has a gently sinuous outline, and is characterized by low banks and gently shelving beaches, which are often thickly strewn with boulders. The banks as pointed out by Richardson, are often built up of drift timber. The northern shore is more uneven, and is indented with several deep bays. The water of Great Slave Lake between Slave River and the Mackenzie, is never entirely clear, as a portion of the sediment brought down by the former stream is held in suspension and drifts slowly eastward for a hundred miles. The impurity of the water is especially noticeable along the southern shore, and the shallowness of this part of the lake is undoubtedly caused by the partial settlement of the suspended material.

Soil and agriculture.

This arm is bordered all around by a flat wooded country, which has been proved to be adapted to the cultivation of barley, and of potatoes and other vegetables. The soil is usually a loam, but in the ridges is often sandy, and in low places passes into a clay. The alluvial lands along Slave River and the grassy plains on Little Buffalo River are the best sections of the district, and deserve the first attention. At Fort Resolution a few acres of land are farmed every year with good results by the Hudson's Bay Company. Mr. Flett, who has charge of this post, informed me that barley is usually sown on the 15th of May, and requires about 110 days to reach maturity. Potatoes are planted about the same date, and are dug about the 15th of September, wheat, according to the same authority, has been tried three times with only one failure. At Hay River, sixty miles west of Fort Resolution, some

potatoes are annually grown by the Indians, and even at Fort Rae, which is situated on a bleak island in the northern arm of the lake in Latitude 62° 39', some gardening has been attempted by the energetic Catholic missionaries who are stationed there. The soil at this place is very stony, and much difficulty was experienced in removing the boulders, and in bringing the ground into a proper state for cultivation. When this was once effected several kinds of vegetables were grown without trouble. Potatoes planted on the 25th May are dug in the middle of September, and yield twenty fold, and the list of garden vegetables raised here includes turnips, onions, cabbages, carrots, radishes, beets and peas. Wheat and barley have not been tried on a large scale, but a few grains were sown at the end of May one season, and became mature, the latter on the 26th August and the former four days later. A less favourable spot for farming purposes, than this rocky island, could scarcely be obtained, and the successful raising of crops here affords a promise that the more fertile lands to the west and south will one day all be utilized.

Ice forms in the bays and along the shores of Great Slave Lake, between the 20th and the last of October, and the whole lake is usually fast by the middle of November. The ice attains a thickness of from six to eight feet. In the spring the disruption of the ice takes place about the 1st of July, but sometimes occurs as early as the 20th of June and as late as the 10th of July. Back states that in a contracted part of the channel between Owl Island and the north shore called Tal-thel-leh, the water is said never to freeze, and his experience proved this to be the case during two winters. A similar occurrence was afterwards noted in the narrows of Lake Bis-tchô.

I remained at Fort Resolution a day, engaged in making preparations, with the assistance of Mr. Flett, for further explorations, and while there examined the shores of the lake in the vicinity of the Fort and along part of Mission Island, but failed to find any rock *in situ*. The shores, however, are plentifully strewn with angular limestone blocks which have evidently not travelled far. These are usually yellowish in colour, but are sometimes dark and bituminous and pass into a calcareous shale. Some of these fragments are fossiliferous, *Fossils*, and hold among others the familiar *Atrypa reticularis*, but I expected to find bedded rocks farther on and made no collection. Meek* describes a number of fossils collected near here by Mr. Kennicott, but whether these were obtained from loose fragments or from rock *in situ* is not evident. The collection contained *Favosites polymorpha*, *Atrypa reticularis*, a smooth *Spirifer (Martinia)*, *Cyrtina Hamiltonensis*,

* Transactions of the Chicago Academy of Science, 1868, page 68.

a *Chonetes*, a small *Productus*, a *Lingula* and a *Proetus*, all characteristic of the Devonian and belonging probably, as stated by Meek, to a horizon very near to that of the Hamilton group. Richardson obtained fossils here which led him to a similar conclusion. Mingled with the limestone are numerous well rounded gneissic and granitoid boulders and sub-angular traps and conglomerate fragments derived from the Cambrian rocks of Owl and neighbouring islands.

Leave fort.

We left the fort on September the 2nd, and made a traverse of three miles across a bay to the mouth of Little Buffalo River, where we were windbound for a few hours. This bay is shallow for a long distance from the shore, and is filled in places with gneissic boulders, on one of which we were driven by the wind, and injured our bark canoe so severely that it was only by dint of energetic bailing that we managed to reach the shore.

Little Buffalo River.

Little Buffalo River approaches Slave River a few miles below Point Ennuyeux, and canoes, by ascending it and making a short portage over to Slave River, avoid the long detour around by the mouth of the latter stream. It runs through a flat country throughout. Half a mile west of Little Buffalo River is a ledge composed principally of flat-lying yellowish brecciated limestone precisely similar to that observed in Bell's rock, a few miles below Fort Smith. This rock holds angular fragments, ranging in size up to a couple of inches in diameter, of both ordinary and dolomitic limestones firmly cemented in a compact calcareous matrix. It yielded no determinable fossils.

Shores of lake.

After repairing our canoe, the wind in the meantime having fallen, we continued our journey, and camped at dusk on a small boulder-lined island, where we were detained the whole of the next day by a strong north-westerly wind. On the 4th we succeeded in getting away again, and after crossing a bay about four miles wide we coasted along the shore, inside the Burnt Islands, to Ile du Mort, where a party of Dog-ribbs are said to have been chased and starved to death by their southern neighbours. From Ile du Mort we crossed two shallow bays, and camped in a good harbour at Sulphur Point. The shores of the lake all along are flat and uninteresting, and only one or two small exposures were observed at the various points at which we touched, although loose fragments of limestone and gneissic erratics are seldom absent. Low terraces running parallel with the beach, and other indications of a former higher lake elevation were noticed in places, and appear to encircle the lake, as terraces were afterward found on the northern shore, and Back mentions their occurrence at the east end, near Fort Reliance.

Sulphur Point derives its name from the presence there of several

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springs which emit a strong odour of sulphuretted hydrogen. The flow ^{sulphur} _{springs.} from these is small, and the effluent water must carry up large quantities of soluble material, as heavy deposits of calcareous tufa occur all around. The water is clear and almost tasteless, and has a temperature of 57° F.

We left Sulphur Point on the 8th, having been delayed three days by a north-west gale, which are very prevalent on the lake at this season, and reached Hay River the same day. Six miles east of Sulphur Point is Buffalo River, a stream of about fifty yards in width, which originates in a large lake situated, according to report, about fifty miles east of Fort Smith. Heavy rapids occur on it in one place, but it is navigable with York boats to its source. Four miles east of Buffalo River is a blunt headland called Point Presse, and between it and Hay River is a wide, shallow bay with sandy shores, into which a couple of small streams flow.

HAY RIVER.

Hay River has never been explored. It is reported to rise near the ^{Hay River.} head waters of the Nelson, or East Branch of the Liard, and to flow in a north-easterly direction for three hundred miles before emptying into Great Slave Lake. Grassy and partly wooded plains extend northwards from Peace River and skirt its southern shores, but do not cross it, and this river may be regarded as practically the northern limit of the prairie country, although small isolated plains occur much farther north in the vicinity of Slave River.

Hay River, like Slave River, enters the lake by several channels, ^{Hay River} _{delta.} and at the extremity of a point formed by the deposition of its own sediment, near its mouth, is an abandoned Hudson's Bay trading post, now occupied by a band of Indians, who assemble there on account of the excellent fishing. For some distance above the post, and while passing through the delta, the river is wide and encloses a line of alluvial islands, but on getting above these it contracts to about one hundred yards in width. Its banks are low and grassy, and the country on both sides is thickly forested. Proceeding up the river the general elevation of the country increases, and the valley becomes higher and wider, and bordering flats make their appearance. The current at the mouth is gentle, but increases in rapidity as we ascend and breaks into riffles on the bars. As we ascend, also, the recent sands and clays of the delta and lower part of the river are replaced by bluish-green soft shales, which rise gradually in the banks until they form bold bluffs along both sides of the valley. These shales are interstratified with ripple-marked and worm-burrowed calcareous sand-

^{Rocks along}
_{Hay River.}

stones and yellowish limestone, and resemble exactly the bluish shales at the rapids on the Liard, and hold similar Devonian fossils. Twenty miles above the mouth, the river, which below has been only moderately tortuous, winds around a tedious double bend, at the elbows of which are high sections of the bluish shales. Four miles farther up some heavy beds of yellowish weathering limestone make their appearance. The valley here is about a quarter of a mile wide, and its scarped sides exhibit the shales in magnificent and continuous sections. Still going on we follow the river around an easterly bend at the upper end of which is a rapid, and then pass for some miles along the base of shale cliffs which are highly fossiliferous. The shales are very soft, almost passing into clays, and the fossils weather out in a beautiful state of preservation. The following species were obtained here:—

Fossils.

- Astraeospongia Hamiltonensis*, Meek and Worthen.
- Aulopora serpens*, Goldfuss.
- Campophyllum ellipticum* (*Chonophyllum ellipticum*, Hall and Whitfield.)
- Cyathophyllum cæspitosum*, Goldfuss.
- Heliophyllum parvulum*, Whiteaves.
- Phillipsastrea Hennahi*, Lonsdale.
- “ “ *Verrilli*, Meek.
- Pachypora cervicornis*, De Blainville.
- Alveolites vallorum*, Meek.
- Arachnocrinus Canadensis*, Whiteaves.
- Spirorbis omphalodes*, Goldfuss.
- “ *Arkonensis*, Nicholson.
- Conchicolites (Ortonia) sublævis*, Whiteaves.
- Hederella Canadensis*, Nicholson.
- Proboscina laxa*, Whiteaves.
- Stomatopora moniliformis*, Whiteaves.
- Ascodictyon stellatum*, Nicholson.
- Paleschara quadrangularis*, Nicholson.
- Ceramopora Huronensis*, Nicholson.
- Crania Hamilt. ni^r*, Hall.
- Productella spinulosa*, Hall.
- Orthis striatula*, Schlotheim.
- Strophodonta demissa*, Conrad.
- Spirifera disjuncta*, Sowerby.
- “ “ var. *occidentalis*, Whiteaves.
- Spirifera cyrtinaformis*, Hall and Whitfield.
- “ *glabra*, var. *Franklini*, Meek.

- Atrypa reticularis.*
 " " var. *aspera*.
Rhynchonella cuboides, Sowerby.
Eatonia variabilis, Whiteaves.
Paracyclas elliptica, Hall.
Schizodus Chemungensis, Conrad.
Euomphalus Maskusi, Whiteaves.
Orthoceras, sp.
Gyroceras (fragment).
Goniatites (fragment) like *G. uniaangularis*.
Primitia scitula, Jones.
Isochilina bellula, Jones.
Aparchitis mitis, Jones.

This assemblage of fossils, according to Mr. Whiteaves, is very suggestive of the "Cuboides Zone" of European writers, and of the Tully limestone of the State of New York, which, according to Prof. H. L. Williams, is its palaeontological and stratigraphical equivalent in North America.

Continuing up the river a band of red shales was noticed in one place near the water level, and a few miles farther on, heavy beds of cream-coloured limestone come in from above and produce at once a striking change in the aspect of the valley.

As we advance the valley contracts and becomes a gorge, and its ^{Hay River} _{gorge} high mural walls buttressed below by an embankment of fallen fragments, appear to almost overhang the stream, while the latter, now reduced in width to a hundred feet, dashes along the boulder-filled channel with bewildering impetuosity. At the lower end of the rapids we left the canoe and scrambled along the beach over high masses of rock to the foot of the portage track. At one point here a graceful effect is produced by a couple of small streams which fling themselves on either hand over the brow of the cliffs bounding the valley and make one clear leap to the floor beneath.

The Portage track leaves the valley at a point where its walls have been worn into a sloping attitude, and leads for a couple of miles across a level, marshy plain, forested with banksian pine and white spruce, to the Alexandra Falls, so named by Bishop Bompas, in honour of the ^{Alexandra} _{Falls} Princess of Wales. The gorge here suddenly ceases, and the river precipitates itself over the hard limestone band through which the latter is cut, with a sheer descent of about eighty-five feet, as measured by a single reading of the aneroid barometer. These falls present a clear unbroken sheet of falling water, and are exceedingly picturesque in

appearance. From their base the river flows along rapidly for about a mile, and then makes a second leap of about fifty feet, below which are three miles of rapids. At the lower falls the cliff is broken down near the centre, and the descent of the water is interrupted by projecting ledges. Above the falls the river loses its valley almost altogether, and has failed to produce more than a feeble impression on the hard limestone beds which floor the surrounding country.

Origin of falls. The falls here owe their origin to precisely the same cause as that which produces the famous falls at Niagara, viz., the superposition of hard limestone on soft shales, and the consequent undermining and destruction of the former effected by the rapid erosion and removal of the supporting beds. I was surprised to find that the rate of retrocession, dating both falls from the same period, has been almost identical.

Comparison with Niagara Falls. The Niagara Falls are generally regarded as having receded six miles since they were brought into existence by the elevation of the country at the end of the glacial period, and on Hay River the distance between the point at which the limestone band makes its first appearance and the lower falls, is almost exactly five miles, and between the same point and the upper falls, six miles. The equality of the work done by the two streams is, however, a mere coincidence, as the factors in the two cases are entirely different. The volume of water which falls over the precipice at Niagara is many times greater than that carried by Hay River, while its erosive power is relatively less on account of its somewhat greater purity.

Limestone at gorge. The limestone exposed along the Hay River gorge has a minimum thickness of two hundred feet, inclusive of a band of shales, which separates it into an upper and a lower portion. It appears to have a light dip up stream. It occurs characteristically in thick massive beds which weather to a light yellowish colour. The heavy beds alternate with laminated bands, which occasionally pass into calcareous shales, and with a uniformly grained well stratified cream-coloured limestone, which resembles specimens I have seen from the limestones of Lake Winnipeg. Fossils are less numerous in the limestones than in the underlying shales, and the same forms appear to characterize both series. At the falls I obtained some specimens of *Atrypa reticularis* and of two specimens of a coral, which is probably *Campophyllum ellipticum*, besides some others which are too imperfect for identification.

Fossils. The eastern outcrop of the band of limestone which crosses Hay River at the falls, forms an escarpment which follows in an interrupted manner the valley of the Mackenzie in a north-westerly direction as far as the Liard, and is the cause of the falls and heavy rapids

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which occur on all the streams which enter the Mackenzie from the southwest between these two points. On the Liard the passage from the harder to the softer formations is marked only by a few light riffles and an accelerated current, but there the proportion of shales to limestone is greater than usual, and the formation is more uniform, and besides, that river carries down an immense amount of sediment, and possesses consequently, greater ability to erode a graded channel, than streams like the Hay or Beaver Rivers, which originate in lakes and carry comparatively pure water. On the northeastern side of the river the continuation of the limestone band is probably marked by the steep terrace-like front of the Horn Mountains, but this ridge has never been examined.

We did not ascend Hay River beyond the falls, which are situated about thirty miles in a direct line from its mouth, and on the 14th we Return to lake. returned to the lake. On the way down I sounded the bars, and on a number of them found less than three feet of water. In high water light draught steamers could ascend as far as the foot of the rapids.

SLAVE LAKE CONTINUED.

From Hay River point we made a traverse of some twelve miles Pte. de Roche. across a moderately deep bay to Pte. de Roche, a narrow gravel and boulder spit which projects for some distance out into the lake, and affords a good harbour against winds coming from the north or northeast. It is strewn with erratics of various kinds, but principally gneissic, and with angular limestone fragments, but no bedded rocks were observed. Leaving Pte. de Roche we coasted along a shallow and often weedy shore to the Desmarais islands. The country adjacent Country south of lake. to the lake is low all along this part, and intersected with marshes, moss-covered muskegs and small lakes, but to the south it rises into a long even ridge called Eagle Mountain. A rock specimen from the mountain which I afterwards obtained, showed it to be composed of a fine-grained yellowish limestone, almost exactly similar to the limestone at Hay River falls. At the Desmarais islands the lake contracts, and the influence of the Mackenzie current becomes apparent. We left the southern shore here and crossed over to the upper end of Big Big Island. Island, an island of some fifteen miles in length, which is situated at the embouchure of the lake and divides the water issuing from it into two channels. The southern channel is four to five miles in width, but is filled with islands. It carries the main body of the water, and is the one used by the steamer, but is everywhere very shallow, and in low water some difficulty is experienced in navigating it.

Big Island is fringed all around its eastern end with a wide margin of drift timber, closely packed together and covered, wherever the interstices have become filled up by the gradual deposition of sand and the decay of the wood, with a heavy growth of willows. The main shores of the lake, as pointed out by Richardson, show in many cases the same structure.

The northern channel is about a mile wide at its narrowest place, and, except in high water, is not navigable for boats drawing more than three feet of water. On the main land, north of this channel, is situated an abandoned trading post, and near it is the productive Big Island fishery.

Slave Lake
fisheries.

The fisheries of Great Slave Lake are of great importance and demand some reference in any account of the lake, however brief. Fish of various kinds can be taken in any part of the lake throughout the year with nets and hooks, but they are especially abundant in some places just before the advent of cold weather. At this season, which usually lasts from the 20th of September to the 10th of October, they leave the deeper parts of the lake, and migrate in vast numbers to certain favored waters, where almost any quantity desired can be obtained. The Big Island fishery supplied Fort Simpson and Fort Providence last year with about 40,000 fish, besides affording constant support to a number of Indians. At the mouth of the Beaver about 20,000 were taken, and the fisheries at the mouth of Hay River, in the bay on front of Fort Rae, and near Fort Resolution, besides other places, yielded corresponding quantities. I estimated the total yield of the lake for the year 1887 at about half a million pounds.

The most abundant and valuable of the fishes of the lake is the widely distributed white fish (*Coregonus clupeiformis*), the superior edible qualities of which are too well known to need description. It is stated by those who have spent some time in the north, to be the only fish on which a person can subsist continuously without becoming satiated with it. The white fish taken at Big Island average nearly three pounds in weight, while those from Fort Rae are much smaller and may belong to a different species. With the white fish are associated the lake trout (*Salvelinus Namaycush*), which often attains a weight of over fifty pounds, but affords too rich a diet for constant use, the inconnu (*Stenodus Mackenzii*), the pike (*Esox lucius*), and the sucker (*Catostomus longirostris*), besides others of less importance. A stray salmon was captured some years ago about forty miles below the outlet of the lake, and is described by Mr. Reid as being identical with the common Yukon salmon, probably *Oncorhynchus Chouicha*, but visitors of this kind are very rare.

On the 19th we left the Big Island fishery and started out to visit the tar springs on the north side of the lake. We first made a long and somewhat risky traverse across a deep bay, and then passed for fifteen miles along a low, swampy shore, lined with driftwood, to Pointe aux Esclaves, a narrow jutting headland of some four or five miles in length, which in windy weather is often portaged by the Indians. On its western side is a small harbour, well protected from winds blowing from any quarter. Beyond Pointe aux Esclaves the shore is bolder and the water becomes much deeper. A bay of some four miles in width separates it from Pointe Brûlée, one of the most exposed and stormiest places on the lake. This point is much dreaded by the Indians, who state that they seldom round it without encountering a gale of some kind. When we passed it the wind was light, but heavy waves, raised by a storm which swept the lake the preceding day, were rolling up from the sea and breaking in a threatening manner along the shore. Outside the fringe of breakers the waves were broad and could be ridden with little danger, but it was only with the greatest difficulty and after we had been once nearly swamped, that I was able to convince my Indians of this, as they seemed to consider that the place of greatest safety was close to the shore. After weathering the point we turned to the north-west and entered a deep bay, near the bottom of which our guide pointed out to us a lobstick which marked the position of the springs of which we were in search. The shore here is rocky, but for some distance east of Pointe Brûlée is bordered with a gravel terrace.

The springs are situated a couple of hundred yards from the shore, at the base of a low limestone cliff, which runs inland from the lake, and are three in number, each of them being surrounded with a small basin, three to four feet in diameter, filled with inspissated bitumen, while the soil and moss for some distance away is impregnated with the same material. A small quantity of pitch is annually taken from these springs and used for boat building purposes, while a much larger supply could be obtained if needed. A sulphur spring resembling those at Sulphur Point on the south shore of the lake, but much more copious, issues from the foot of the cliff in close proximity to the bituminous springs, and feeds a considerable stream.

The rock through which the petroleum ascends here is a heavily bedded greyish, rather coarsely crystalline cavernous dolomite, and is entirely unlike the bituminous beds south of the lake and down the Mackenzie, which in most cases consist of calcareous shales. The dolomite is everywhere permeated with bituminous matter, which

collects in the numerous cavities, and oozing up through cracks, often forms small pools on the surface of the rock.

The age of the bituminous beds here could not be clearly ascertained, as they are entirely unfossiliferous, but it is altogether likely that they are older than the Devonian shales and limestone which outcrop along the southern shore, and are more nearly related to the dolomites which underlie the fossiliferous Devonian beds at the Nahanni Butte and at other places. The presence of bitumen in such abundance here also suggests an anticlinal which would bring up lower beds.

Tar springs.

Sulphur and tar springs are reported to occur at a point about half way between this and Fort Rae, but as I did not hear of them until I had left the lake, I was unable to visit them. A tar spring is also known to exist under the surface of the water in the deep bay immediately east of the Big Island fishery, as many of the boulders and rocks along the shore in this neighbourhood are coated with bitumen which has been washed ashore, and hummocks of ice stained with the same material are often observed. On the south shore bituminous shales and limestones outcrop at several points, and it would thus appear that the oil-bearing beds underlie the whole western part of the lake.

Glacial groovings.

The limestones along the shore near the tar springs show glacial groovings and oblong rounded hummocks, running in a general east and west direction, or nearly parallel to the shore line at this point. At Fort Rae, which I afterwards visited in the winter time, the few hummocks which appeared above the snow seemed to run about S. 30° W., or diagonally across the arm of the lake on which that fort is situated.

We left the tar springs on our return journey at noon on the 20th, and reached Pointe aux Esclaves the same night; here we were delayed for a day by a gale of wind, but on the 22nd got away, and by vigorous paddling against a head wind, succeeded in reaching Big Island fishery the same night.

THE MACKENZIE RIVER.

GREAT SLAVE LAKE TO FORT PROVIDENCE.

Mackenz'e River.

Length of river.

The Mackenzie River on which we now enter is the second river in length and size of basin, but the third in actual discharge, on the North American continent, and ranks among the first dozen rivers of the world. The length of its watercourse from its source in the "Committee's Punch Bowl," near Mount Brown, by Athabasca and Slave

River, to the sea is 2,560 miles, but the length of the section to which the name is restricted is only about 1,000 miles. It drains an area of 677,400 square miles, and has an approximate discharge at a medium stage of the water, according to some rough measurements made by the writer of 500,000 square feet per second. Its basin is traversed for nearly 1,300 miles by the Rocky Mountains, and the Mackenzie is probably unique among the rivers of the world in the fact of having a large proportion of its basin situated on the further side of a great mountain chain. Two of its principal tributaries, the Liard and Peace Rivers, pierce the Rocky Mountains and drain large areas beyond, while the third, the Athabasca, originates in the heart of the same range, and is confined entirely to the eastern slope. The country from which the Mackenzie draws its supplies is of the most varied description, and includes part of the broken plateau region west of the Rocky Mountains, the Rocky Mountains themselves through fifteen degrees of latitude, the northern part of the prairie district and the wooded and moss-covered country, which succeeds it towards the Arctic ocean, while tribute is also drawn from a wide belt of rough Laurentian country on the east, and from a portion of the "Barren Lands." From Great Slave Lake to the sea the Mackenzie is an imposing stream, averaging about a mile in width, with occasional expansions for long distances to twice this size. It is characterized by the comparative purity of its water, by its long straight reaches and by the absence of sudden bends. Its valley is usually shallow, and follows closely all the sinuosities of the stream, without the intervention of large flats. Clusters of islands obstruct its channel in a number of places, and are met with at intervals all the way down, while ranges of lofty mountains run parallel with it for part of its course, and form a fitting background to this king of northern waters.

The Mackenzie on issuing from Great Slave Lake has a width of from seven to eight miles, but is shallow and filled with islands. We passed down through the channel north of Big Island, and found the water so shallow that our canoe frequently grazed the bottom several hundred feet from the shore. In very low water loaded York boats are unable to float down this channel from the fishery, and are obliged to go around the east end of Big Island and come down the southern channel, where the water is somewhat deeper. The shore is low and fringed in many places with marshes, which are evidently submerged when the river is in flood. The low elevation of the country all around the east end of the lake makes it difficult to understand the terraces which border it at intervals, as a change in the elevation of the water

Principal tributaries.

Character of Mackenzie.

Low shores.

of the lake sufficient to produce these without some corresponding change in the elevation of the adjacent country would flood all the lowlands to the east, and create a channel of enormous width and carrying power. A detailed study of the lake, and the lake shores will, however, be necessary to solve this and the many other problems connected with its origin and history.

Fifteen miles from the lake the islands cease, and the river has contracted to about four miles, which diminishes rapidly to less than two miles as we proceed, while at the same time the current gradually increases in strength, and thirty miles from the lake is running at the rate of over four miles an hour. Some distance farther on a large island blocks the way, and the main body of water turning to the right, falls over what is commonly called "the rapid," but is scarcely one in the ordinary sense of the word, as although the current is swift it is quite smooth, and is ascended by the steamer "Wrigley" without difficulty. On the southern channel strong rapids are stated to occur.

Between Great Slave Lake and "the rapid," the country bordering the river is generally flat, with numerous marshes and muskegs separated by reaches of forest. The valley of the river is shallow, with low banks seldom exceeding thirty feet in height. Sections of a yellowish boulder clay were seen in a number of places, and near "the rapid" small exposures of the same bluish shale from which Devonian fossils were obtained on Hay River appear at the surface of the water.

Arrive at Fort Providence. At "the rapid" is situated Fort Providence, where it had been arranged that I should pass the winter. I arrived there on the 24th of September, and was kindly received by Mr. Reid, the officer in charge, and by Mr. Scott, also of the H. B. C., who was staying with him, and hospitably treated by them and by the members of their households while I remained. It will be unnecessary here to more than refer to the events of the winter which passed pleasantly and quickly if somewhat monotonously. While staying at the Fort the traverses of the preceding summer were platted and a meteorological record kept, which will be found in the appendix. Some rough exploration was also undertaken.

Soil and agriculture. Fort Providence is surrounded by flat arable lands, of good quality, and capable of producing excellent crops. Agriculture is engaged in here both by the H. B. Company and the R. C. Mission, and large quantities of farm produce are annually raised. Wheat has been sown at the H. B. Company's farm for nine years, and, according to Mr. Reid, has never been a complete failure, although on some occa-

Current of
river.

Rocks along
river.

Arrive at Fort
Providence.

sions it has been slightly touched by summer frosts. It is usually sown about the 20th May, and requires about three months to ripen. As much as twenty-nine bushels has been obtained from one bushel sown. Barley is a sure crop. It is sown at the same time as the wheat, and is ripe almost a week earlier. Potatoes are planted between the 16th and 25th May, and are taken up about the 20th of September. Turnips, cabbages, beets and numerous other garden vegetables are grown with scarcely greater difficulty than in latitudes ten degrees farther south. The soil is a stiff clay, with in some places surface beds of sand, and is seldom thawed out to a greater depth than six feet. The muskegs which cover a considerable proportion of the country back from the river are permanently frozen at less than two feet from the surface. It must be borne in mind, however, in this connection, that the histories of other districts have shown that when the country is cleared and the moss burnt off, the penetrative powers of the summer thaw is at once greatly increased, and lands have become productive, which at first appeared hopelessly barren.

A number of cattle are kept at Fort Providence, but require to be fed about seven months in the year. Hay of excellent quality is obtained in abundance from neighbouring marshes.

FORT PROVIDENCE TO LAKE BIS-TCHÓ.

On the 3rd of January an opportunity offered, of which I availed myself, of making an exploratory trip to the southwards from Fort Providence. A party was sent out with three dog trains for the purpose of bringing in furs from Lake Bis-tchó, and Mr. Reid kindly allowed me to accompany it. A traverse was made of the route passed over, but this is necessarily of a somewhat rough character, as the shortness of the days forced us to do most of our travelling at night, and besides, jogging behind dogs at the rate of five miles an hour, with the temperature at forty degrees or more below zero, is not favorable to an accurate estimate.

Trip to Lake Bis-tchó.

Character of traverse.

From the fort we made our way with difficulty over the hummocky surface of the main channel of the river, here about a mile wide, to a large spruce covered island, which we traversed, and then crossed the back *Chenal* to the mainland, where we camped, as our late start prevented us from making more than a single "spell." In travelling in this country in mid-winter an effort is usually made to start about 3 a.m. in order to get the day's work completed by noon, the short afternoon of about two hours being required to prepare camp and cut wood for the night and morning. On the 4th we were off in good

time, and quickly passing through the belt of spruce which margins the river, came out on a wide muskeg, on the farther side of which the spruce woods recommenced and continued to the base of a steep escarpment which crossed our way at a distance of about thirteen miles from the river. This escarpment runs parallel with the river, and is doubtless the northern edge of the same limestone band, or of the lower portion of it, over which Hay and Beaver rivers plunge at their falls. After making the ascent the barometer showed an elevation of 300 feet above the river. From the top of the escarpment the trail leads for some miles through a Banksian pine forest, beyond which is a wide spruce and tamarac flat which extends to Lake Ka-ki-sū; on the farther side of which we made our second camp, after travelling about thirty miles. Lake Ka-ki-sū is about four miles wide at the west end, where we crossed it, and is at least ten miles in length. Beaver River passes through its eastern end, according to a sketch which Chief Nelson, of the Trout Lake Indians, drew out for me.

On the 5th we climbed about a mile from camp a second steppe or sudden rise in the general elevation of the country. This escarpment runs northwards, with a height of 300 feet, parallel to the southern shore of the lake. An exposure of yellowish-weathering compact limestone, lying in a horizontal position, was observed in the couleé up which the trail led, but proved to be unfossiliferous.

The elevated country behind this second escarpment is covered for some miles by a Banksian pine (*Pinus Banksiana*) forest. This tree grows to a larger size here, and its branches are more irregular and extend out straighter from the trunk than is usual in more southern latitudes. It frequently attains a diameter of over two feet, but its wood is very soft and is regarded as much inferior to that of the white spruce (*Picea alba*), which affords by far the greatest part of the timber used in the district. Leaving the pine woods the trail leads through a succession of spruce swamps, open muskegs and wide brûlé reaches, which continue for the next twenty miles. A small tributary of Beaver River winds through this part of the country. After crossing it we passed over a pine and aspen ridge, and then descended into a swampy partly wooded plain, which we entered for four or five miles, and then camped. We passed on our left, during the day, the northern end of Lake Tu-thl-i-nā, an expanded portion of Beaver River, and in the same direction, a range of hills, apparently running nearly north and south, was observed whenever an unobstructed view could be obtained. Early on the 6th we passed through a wide belt of spruce woods and reached Beaver River. This stream, where we crossed it, is about a hundred yards wide, and has a somewhat sluggish current. It

Steep
escarpment.

Lake Ka-ki-sū.

Exposure of
limestone.

Pine forest.

Spruce
swamps.

Beaver River.

is reported to originate at the foot of a high ridge, which was now plainly visible to the south. From Beaver River we made our way for eighteen miles across a partly wooded, partly open country, intersected with muskegs, and camped in the dense spruce woods which skirt the base of the heights referred to above. The 7th was occupied in crossing this ridge, which marks the front of a third steppe, and rises to an elevation of 1,150 feet above Beaver River. The ascent is at first gradual, but near the top there is an abrupt rise of some hundreds of feet. The summit is covered with irregularly disposed steep sided hills and low interlacing ridges, which are probably of glacial origin, and suggest a comparison with the surface configuration of the Missouri Côteau of the southern plains. No exposures were observed here, and if any existed they were concealed by the snow.

From the summit we made a descent of about 200 feet to camp, and on the following day, after passing some small lakes, made a traverse of over thirty miles across a desolate looking plain, scantily covered with spruce and tamarac, to Lake Bis-tchô, on the farther side of which we found the Indian camp of which we were in search.

Lake Bis-tchô (Big Knife) is reported to be about thirty miles in length and from six to eight in width. It empties into Black River, a tributary of the Liard. At its western end it contracts in one place to a couple of miles and then opens out into a deep bay, which gives it the fancied resemblance to a knife, from which it derives its name. It has low banks, and is surrounded by a flat country wooded with spruce, birch, tamarac, &c., of fair size. Eight or ten miles to the south is a high ridge, across which the Indians make a portage to Hay River.

The latitude of Lake Bis-tchô, from a meridian altitude of the sun taken under somewhat unfavorable circumstances, was found to be $59^{\circ} 43' 30''$.

We commenced our return journey on the 10th and reached the fort without mishap on the 15th.

FORT PROVIDENCE TO FORT RAE.

On the 21st of January a trip to Fort Rae was undertaken in company with Mr. Camsell and a number of officers of the Hudson's Bay Company. We reached our destination on the 25th, and after a pleasant stay of a few days with Mr. Wilson, the genial officer in charge, I started back on the 29th. Fort Rae has been referred to in connection with a previous description, and some agricultural statistics given. It is situated on an island in the northern arm of Great Slave

Fort Rae.

Lake, and in winter presents a somewhat inhospitable appearance to the approaching traveller, but in summer its surroundings become more agreeable. It is resorted to for trading purposes by several hundred Dog-rib Indians, whose hunting grounds extend from the north shore of the lake far into the "Barren Grounds." Fort Rae is surrounded by a deer country, and is looked on rather as a provision post than as a fur post, although it also ranks high in the latter respect. In the winter thousands of the "Barren Lands" Caribou, which have been driven south by the severity of the climate, are slaughtered in its vicinity, and their flesh converted into dry meat for use in the district.

Rocks around
Fort Rae.

The unfavorable season and depth of the snow prevented me from obtaining much information in regard to the geology of the interesting country around Fort Rae, but some notes were made. The line of junction between the Archean schists and the Palaeozoic limestones passes about two miles east of the fort. Exposures of both systems were observed within a distance of half a mile, but the actual contact was not seen. The hummocks of Archean rock which projected above the snow consisted, so far as my limited examination went, exclusively of a reddish coloured, medium grained biotite granite. The hummocks are glaciated, and have their longer axes orientated in a general S. S. W. and N. N. E. direction, which would go to show that the abrading glacier was deflected to some extent down the arm of the lake, as the groovings at the tar springs, noted on a previous page, have an approximate east and west direction. The limestone beds exposed in the vicinity of the fort have a horizontal attitude, and are usually of a somewhat massive character, and form cliffs running along the shores, but are also sometimes flaggy. They are yellowish in colour, are very compact, and are generally indistinguishable in appearance from the limestones which overlie the fossiliferous Devonian shales south of the Mackenzie. They are fossiliferous, but no specimens perfect enough for identification were obtained.

Country
between Fort
Providence and
Fort Rae.

On the way back from Fort Rae an estimated traverse was made, but the country is generally monotonous and uninteresting and will not require much description. It is everywhere flat, the barometer never indicating a greater height than 290 feet above the lake, and is covered with lakes and marshes, separated by belts of spruce and pine, and by partly wooded plains and bruleés. No exposures of rock of any kind were seen on the way across. After leaving the lake on the 29th we passed through a thick spruce forest for a couple of miles, the surface rising gradually as we proceeded to an elevation of 150 feet above the lake, and then through a region more sparsely clad with alternating

groves of spruce, poplar, birch and alder. On the 30th the most noticeable feature of the day's journey was the number of small lakes which we crossed, and which dotted the face of the country on both sides of the trail. Some excellent spruce was seen in the middle of the day, but this thinned out and was replaced by muskegs before reaching camp. On the 31st the trail led through a well wooded country most of the way. In the forenoon of this day we made a traverse of six miles across Birch Lake, the largest lake seen on the route. On the 1st of February we made our way through the Grand Brûlée, the scene of a former destructive fire, and encamped on the far side of Lake Ta-di-tha, and on the 2nd crossed three wide prairies, with the intervening timber belts, and arrived at Fort Providence.

Travelling with dogs in northern latitudes is pleasant enough when one is comfortably ensconced in a cariole and looked after by a driver, ^{Travelling with dogs.} but presents itself under quite a different aspect when one is obliged to follow up on foot. The constant use of the snowshoe is almost certain to result, in the case of the novice, in sore feet, and a careless tying of the strings may bring on the dreaded "*mal de raquette*," when every step becomes an agony; and as extra supplies are never provided, no halt can be made, and the unfortunate sufferer is obliged to limp along at the rate of thirty or forty miles a day until the journey is completed. No tents are ever carried in winter, and the outfit taken along is limited strictly to absolute necessities, even articles for washing being dispensed with by those who are desirous of being styled "men of the north."

FORT PROVIDENCE TO FORT SIMPSON.

After returning from Fort Rae I remained at Fort Providence until the 1st of May, and then proceeded down the river to Fort Simpson <sup>Proceed to
Fort Simpson.</sup> with dogs. The weather, which had remained cold and wintry up to this time, suddenly turned warm, and the walking became exceedingly disagreeable and fatiguing. We travelled at night, but even then were obliged to wade through slush most of the way, as a crust sufficiently hard to bear us only formed for a short time in the early morning. We were six days making the trip. No survey was made along this part of the route, as the course of the river had been previously laid down by Franklin and others, and the necessity for travelling at night made it impossible for me to attempt any improvement on their work.

The Mackenzie, from a point four miles above Fort Providence down to the Little Lake, a distance of twenty miles, is split up into a number of channels which have a spread of over four miles. The numerous

<sup>The Mackenzie
below Fort
Providence.</sup>

islands in this reach are low, and as a rule are densely covered with spruce. At the upper end of some of the islands great hills of clay and boulders were noticed, which had evidently been piled up by the action of the river ice. The shores of the river are low, and show exposures of boulder-clay, underlaid in some places by bluish Devonian shales. At the Little Lake, which is simply an expansion of the river, the Mackenzie is joined from the north by Willow River. This stream is about fifty yards in width, and originates in the rear of the Horn Mountains around the eastern end of which it flows. It is navigable by canoes for a long distance, but heavy rapids are stated to occur in its upper part. The mouth of Willow River has been used for the last two seasons as a winter harbour for the steamer *Wrigley*, on account of the fact that the ice on streams coming from the north breaks up in the spring with less violence than on those coming from the south.

Horn
Mountains.

The Horn Mountains, which begin abruptly about thirty miles north of the Little Lake, and are seen from various points along the river nearly all the way to Fort Simpson, have the character of a simple escarpment. They present a steep face to the south, but to the north slope away very gradually. A wide marshy plain is reported to exist at their base, between which and the river the country is well forested. To the south similar but lower escarpments, among which is Trout Mountain, extend parallel to the general course of the river.

River below
Little Lake.

From Little Lake the Mackenzie continues wide and sluggish to what is known as the "Head of the Line," the point at which oars are substituted for the tracking line in ascending the river, beyond which its current becomes more rapid. Forty miles below the lake we reached Yellow Knife River, and a few miles farther on, after rounding a broad bend, came to Trout River. Both of these streams come from the south, and are reported to head in large lakes. From Trout River we followed around a northerly bend, and then crossed a long straight reach to the head of the portage. From this point a short cut leads across to the Liard, and down it to Fort Simpson, but as the thaw had made this impassable, we were obliged to take the longer route around by the river, and pick our way through the numerous "*bourdillons*" which roughened the surface of the river almost all the way to the Fort.

Geology.

Between the Little Lake and Fort Simpson, sections of yellowish-weathering boulder-clay are of constant occurrence and underlying it are exposures in a few places of the same bluish Devonian shales, which have been traced all the way from Hay River. In descending the river the shales lose their characteristic greenish-blue colour to some extent, and become darker and harder, and weather into steeper

slopes, but that the two varieties are of the same age is shown by their occurrence together on the Liard.

Dr. Richardson, who descended the river in the summer time, and had a better opportunity of examining the banks, describes the geology of this part of the river in the following terms:—

"In the few spots where sections of the strata are visible a bituminous shale containing many fragments of the small pteropodous shell *Tentaculites fissurella*, indicates the formation to be the same with that on the Athabasca River and Slave Lake, which has been said above to be probably Marecellus shale. Between the old fort and Hare Skin River the basis of the bank is formed of a greyish-green shale clay, which under the influence of the weather breaks into scales like wacke, and at last forms a tenacious clay. The whole banks of the river seem to belong to a shale formation, but from the want of induration of the beds they have crumbled into a slope more or less steep, and the capping of clay, sand and boulders, has fallen down and covered the declivity."*

The two escarpments of the Horn Mountains and Trout Mountain which border the river on either side, evidently represent the outercrop of the same limestone which overlies the shales at the Hay River falls, and south of Fort Providence, as there is no reason to suspect that the succession here is different to that which obtains at those places.

FORT SIMPSON.

I arrived at Fort Simpson on the 6th of May, and was cordially welcomed by Mr. Camsell and by the other officers at the Fort, and as I intended to remain here until the ice broke up, and then to proceed by water, Mr. Camsell at once gave orders for a boat of the requisite size to be built.

Fort Simpson is beautifully situated on an island at the mouth of the Liard, and is the headquarters of the fur trade on the Mackenzie. The various buildings are arranged around three sides of a square, open towards the river, and are of a size commensurate with the commercial importance of the place. In former days all the goods intended for consumption in the district were first brought here and then distributed to the various posts, but since the advent of the *Wrigley* this has been done away with to a large extent, and all the posts which can be reached by the steamer are now supplied directly. Like the other posts Fort Simpson has its farm, and according to some statistics which I received from Mr. Laviolette, the various crops

* Journal of a Boat Voyage through Rupert's Land, Vol. I, p. 181.

raised, with the exception of wheat, which does not ripen, and the dates for planting and reaping, are much the same as those previously stated for Fort Providence. Potatoes are usually planted between the 15th and 20th of May, but this season (1888) were not put in, owing to the unusually late spring, until the 28th, and require about four months to mature. In an ordinary year forty bushels of seed will yield from six to seven hundred bushels, but the crops are sometimes injured by summer frosts. Barley, which is the only cereal grown, is sown about the 20th of May, and is usually ripe by the 20th of September. No difficulty is experienced in raising such garden vegetables as cabbages, turnips, beets, &c., and Mr. Camsell seemed sanguine that even melons and tomatoes would ripen if properly tried. The soil here is a stiff clay loam.

Warm weather. The warm weather which commenced on the 1st of May continued throughout the month, and under its influence the snow quickly disappeared, and the spring advanced with astonishing rapidity. On the 20th of April, the first day the temperature rose above freezing point for nearly six months, the barking crow (*Corvus Americanus*) made its appearance. The raven (*Corvus corax*) had remained throughout the winter. On the 1st of May some Canada geese (*Branta Canadensis*) were seen at the edge of an open place in the river, accompanied by a flock of mergansers and other ducks. The 4th brought the robin (*Turdus migratorius*) and some sparrows, and on the 5th the wavers (*Anser hyperboreus*) which usually lag a few days in the rear of the Canada geese, commenced to wing their way northwards, and in a couple of days were passing in such numbers that flocks were rarely out of sight. The first goose was shot at the fort on the 5th, the successful marksman receiving, according to immemorial custom at the Hudson's Bay establishments, a present of a pound each of the two luxuries of the country, tea and tobacco. By the 10th the ground was bare in many places, and such late birds as the swallow and plover had arrived.

DISRUPTION OF THE LIARD ICE.

Break up of
the ice on
northward
flowing
streams.

On the 13th, the great event of the spring at Fort Simpson, the disruption of the ice on the Liard occurred.

Northward flowing rivers, like the Liard, relieve themselves from their winter fetters in a somewhat peculiar but forcible manner. The influence of the advancing spring is first felt near their sources, and as they break up there the fragments of ice are floated down, until they come in contact with the firm ice, where dams are formed, behind which the water accumulates until it acquires sufficient power to burst

the icy barriers, and in the onrush of the escaping flood the river is usually cleared for some miles below. Another ice dam is then formed and broken in turn, and the same operation is repeated at intervals all the way to the sea. If the dam forms where the river is confined between high banks, while the country above is lower, destructive floods are apt to result, and it is this fact which creates a general feeling of uneasiness at those posts along the river which have low situations, until the danger is past. Fort Simpson has never been injured in the fifty years or so of its existence on the present site, although on one occasion the water overflowed the bank, but Fort Good Hope in 1836 was entirely destroyed, and Fort Liard and some of the other posts have been seriously threatened.

The breaking up of the ice at the junction of the Liard and the Mackenzie is worth witnessing. The first shove occurred about noon, and was announced by a dull roar coming from the direction of the *Gros Cap*. On hurrying out we found that the Liard ice, which a few moments before had formed an unbroken sheet, was now crushed into fragments, and was moving slowly forwards. Huge cakes of ice under the enormous pressure were constantly raising themselves on end and falling, and the whole mass urged forward by the terrible energy of the piled-up waters behind, was battering a way across the Mackenzie. The ice of the latter, fully five feet thick, and firm and solid as in mid-winter, was cut through like cardboard, and in a few moments two lanes were formed across its entire width, while a third was opened for some distance below, before the force of the rush was exhausted and the movement ceased. In the afternoon the crashing of trees, in a channel behind the island, concealed from view by the intervening forest, was distinctly heard, and showed that a temporary vent had been found there, and in front of the fort intermittent fountains played at intervals from holes and crevices in the ice. At midnight the dam at the mouth of the Liard gave way, and the massive crystal structure was hurled by the liquid energy behind it against the firm ice in front with such force that the whole sheet, for some miles below the fort, was crushed into fragments by the impetuosity of the assault. After the break a stream of icy hummocks poured in tumultuous confusion past the fort. The velocity of the stream, however, gradually diminished as the river became choked below with cakes of ice, and soon ceased altogether. The situation on the island was now somewhat critical, as on the strength, or rather weakness, of the newly formed dam, depended our safety. If it was able to withstand a pressure of forty feet of water, no uncommon event, the island, from which there was no escape, would be submerged. Slowly but steadily the water

Liard ice comes down.

with its icy load crept up the slopes, until the crests of the hummocks peered ominously over the banks. An interval of anxious suspense followed, during which the water rose within a foot of the surface, and then to our intense relief the ice commenced to move down the river, a sure sign that the dam below was broken. After the shove the water fell quickly and all danger of a flood was over.

In the lower part of the river the ice was broken up at Fort Wrigley on the 18th May, at Fort Norman on the 19th, and at Fort Good Hope on the 21st. The ice on the river above Fort Simpson, between the mouth of the Liard and Great Slave Lake did not, however, move until after the 1st of June.

FORT SIMPSON TO FORT NORMAN.

Leave Fort
Simpson.

Ice cliffs.

Appearance
of river.

Rocks along
valley.

On the 28th of May I left Fort Simpson with a couple of Indians whom Mr. Camsell had engaged to accompany me as far as Fort McPherson, and commenced the descent of the Mackenzie. The river was still full of floating ice, and wherever jams had occurred high cliffs of the same material lined the banks and were constantly falling in as they became undermined by the water, which had now a temperature of several degrees above freezing point. These ice cliffs at this season of the year have sometimes a continuous stretch of ten to fifteen miles along the banks, and on one or two occasions we were almost swamped by sudden squalls before we could get past them and find a landing place. Opposite Fort Simpson the main channel of the Mackenzie is almost exactly a mile wide, and it maintains and often exceeds this width for many miles below. Its course, as far as the Great Bend, a distance of seventy miles, is N.N.W., and its current in average stages of the water has a velocity of about four miles an hour. The banks of the valley appear low owing to the great size of the river, but in reality have often a height of two hundred feet or over. The appearance of this part of the Mackenzie, and of the unending spruce forests which border it is monotonous and uninteresting, and is only relieved by the majesty inseparable from the silent sweep of a river of its magnitude.

Four miles below the fort on the right hand bank is an exposure of the same Devonian shales which were noticed opposite the mouth of the Liard. They are overlain by arenaceous boulder-clay and by sand. Two miles farther down, Martin River comes in from the south, and below it are sections of stratified sands belonging to the upper part of the glacial deposits. Scarped banks, showing boulder-clay overlaid by sands, appeared at intervals as we descended the river,

but no further exposures of the underlying rocks were noticed until the Great Bend was reached.

Twenty miles or so above the Great Bend the elevation of the country suddenly decreases, and we enter a flat plain, evidently alluvial in its origin, which extends almost to the foot of the mountains. The river here widens out and encloses numerous islands, and its banks are low and sandy. The Liard crosses a similar plain in that part of its course where it skirts the Rockies, and the two plains as stated in the description of that river may be connected by a continuous depression running along the base of the mountains.

The Nahanni River joins the Mackenzie at the Great Bend. This Nahanni River stream is reported to head near the sources of a second stream of the same name, which empties into the Liard at the Nahanni butte, and canoes can be taken from one to the other. It is upwards of a quarter of a mile wide at its mouth, but is shallow and filled with islands and gravel bars.

After leaving Fort Simpson the Mackenzie gradually approaches the mountains, and at the Great Bend it strikes against them, and is then deflected to the north. I spent a day here on a tramp in A walk inland land. A walk of about four miles across a marshy spruce-covered plain intersected with muskegs, and over numerous drifts of fast melting snow, brought us to the foot of the mountain, and a further walk of a mile up a gradually increasing gradient to the cliffs which lined its summit, where a stiff climb of about 500 feet awaited us, or rather one of us, as the Indian I had brought along declined risking his neck and remained below. The mountain I ascended has a height above the river, measured by the aneroid barometer of 3,000 feet, but is greatly exceeded in this respect by some of the ranges in the rear, which must approach 5,000 feet in height. From the summit the usual prospect presented itself. To the N. E. a vast expanse of forested country diversified with occasional lakes and marshes spread beyond the line of sight, and in an opposite direction appeared a multitudinous succession of partly snow-clad limestone ridges. The limestones here have a general westerly dip at low inclinations, and in some of the flat-topped ranges of the interior appear to become nearly horizontal.

The first range at this point, the only one I had an opportunity of examining, is composed throughout of a great series of magnesian and ordinary limestones. The lowest beds seen consist mainly of heavily bedded dolomites of the Castle Mountain type alternating with some limestone. The dolomites are rather coarse-grained as a rule, faintly striped in places, and some beds are cavernous, the interior of the cavities being lined in some cases with quartz crystals, and in others

with calc spar. In the upper part of the section the dolomites are replaced to a great extent by greyish limestones, but are never entirely absent. No fossils were obtained in the lower part of the section, and the upper beds yielded only some badly preserved corals, somewhat resembling those which characterize the Intermediate limestone of the Bow River section. The whole series is evidently older than the flat lying Devonian shales and associated limestones exposed along the river, and I have little hesitation in referring the lower part of it at least, mainly on lithological grounds, to the widely distributed Castle Mountain group. The upper part has a greater resemblance to the Intermediate limestone, and probably belongs to the lower part of the Devonian.

On the way back to the river I found *Anemone patens*, the first flower of the season (May 31), in full bloom in sunny exposures along the base of the mountains.

Continue on
down river.

On June 1st we continued on down the river, and after passing the mouth of the Nahanni River bent away to the north. The river is now bordered on the left, at a distance of three to four miles, by lofty ranges of steep-faced mountains, and on the right by a wooded plain. Twelve miles below the Nahanni River we passed the mouth of a large stream coming in from the west, and twenty miles farther on, after travelling for some distance behind a long island, reached Willow River. Since leaving the Great Bend the banks have been low, and with the exception of boulder-clays have afforded no exposures.

Mackenzie
enters
mountains.

At Willow River the Mackenzie may be said to enter the mountains, as a range, low at first, but soon attaining a height of 4,000 feet or over, now appears on the right-hand side. This range does not cross the river, and must mark the beginning of an entirely new line of disturbance. It affords a good example of the *echelon* arrangement so frequently affected by the Rockies. On the left-hand side, the mountains have receded to some distance from the river, and are flanked by a high wooded ridge, behind which some naked limestone peaks can be seen.

Fort Wrigley.

Four miles below Willow River a high hill abuts against the right-hand bank of the Mackenzie, the face of which is scored by a deep coulée, cut out of soft dark shales, interstratified with some ironstone. These shales are unfossiliferous, but resemble exactly some which I afterwards found below the "Rock by the River side," and which held Devonian fossils. Fifteen miles farther down we reached Fort Wrigley, an outpost of Fort Simpson. Opposite the fort are a couple of small islands, built of heavily bedded dark grey limestone, holding *Zaphrentis* and *Atrypa*. Between the islands and the right-hand bank

rapids are stated to occur in low water, but they are not evident when the river is in flood.

Seven miles below Fort Wrigley, stratified sands and gravels, ^{River below} _{Fort Wrigley.} cemented by carbonate of lime into a hard conglomerate, were observed to overlie the boulder-clay. The river at this point has a width of three-quarters of a mile and a current of five miles an hour. The valley is about 500 feet deep. Rugged ranges of lofty mountains border it on either hand at a distance of about fifteen miles, and are separated from it by a plain relieved occasionally by isolated hills, small ridges and plateau edges. Four miles below the conglomerates just noted an exposure of Devonian shales occurs, below which boulder-clay and associated sands and gravels occupy the banks all the way to near the "Rock by the River side." Three miles above this rock are a couple of well marked terraces. These form a somewhat unusual feature in the structure of the valley and were noticed and described by Richardson.*

"Three miles higher up the stream there are two river terraces, more complete than any I noticed elsewhere on the Mackenzie, though in many places a high and low bank can be traced. These terraces are composed of fine sand, and the slope between them is so steep as to require to be ascended on all fours. Both terraces are very regular in their outline, and are covered with well grown *Pinus Banksiana*. The uppermost is about two hundred and fifty feet above the river."

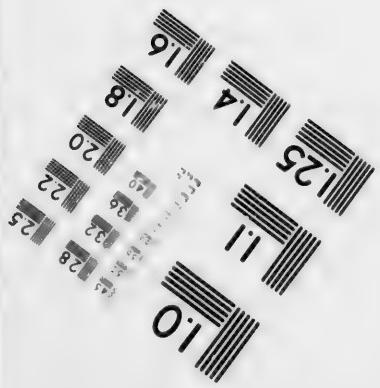
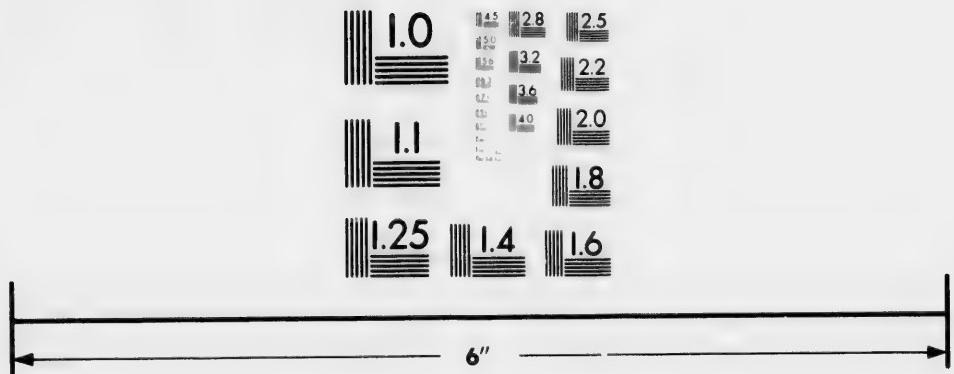
The "Rock by the River side" was ascended in 1789 by Sir Alexander Mackenzie. It forms part of a small range which crosses the river here in a direction somewhat diagonal to the general course of the main ranges. It presents a steep face towards the river, above which it rises to a height of 1,500 feet. This hill is built mainly of limestones, striking almost north and south, and dipping to the west at an angle of between 60 and 70 degrees. The lowest rocks seen here consist of unfossiliferous dolomites, associated with some hard quartzites, all of which I referred to the Castle Mountain group. Above these come a couple of thousand feet of the greyish and bluish well bedded limestones of the Devonian. Some of the beds of this terrane are almost exclusively composed of corals of various kinds, and in others I obtained some specimens of *Productella aculeata*, var. *cataracta*, an *Actinopteria*; a *Paracyclas*, a fragment of a *Gyroceras*, and the pygidia of a couple of trilobites.

Some of this limestone is slightly bituminous, and a mineral spring said by Richardson to resemble sea water in its composition, trickles down over its face.

* Journal of a Boat Voyage through Rupert's Land. Vol. I, p. 185.



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Saskatchewan
gravels.

Immediately below the "Rock by the River side" is a section showing stratified sands and gravels, overlaid by a heavy bed of typical boulder-clay. Those beds occupy the same position as the pre-glacial gravels so extensively developed in the basin of the Saskatchewan, and to which I have elsewhere applied the name of the Saskatchewan gravels, and it will be as well to retain the same name for them here. On the southern plains this gravel is composed almost exclusively of quartzite pebbles, but here it contains in addition pebbles of limestone and of gneiss and granite, all well rolled. Six miles below the "Rock by the River side" is a cut bank about 250 feet high, showing dark greyish shales, interstratified with ironstone and holding Devonian fossils. These shales are horizontal, but are soon cut off by a pre-glacial depression filled with stratified sands and gravels. Six miles farther down exposures of greyish-green Devonian shales appear again and recur at intervals for several miles, and are then succeeded by the stratified sands and gravels of the drift which continue to the Blackwater and beyond.

Visit plateau.

Ten miles above the Blackwater a visit was made to a small plateau which here borders the river at a distance of three or four miles, and which showed exposures, which from the river resembled sandstone. The valley of the Mackenzie here has a depth of two hundred feet. After leaving it we crossed a level plain which stretches eastwards to the foot of the plateau. This plain proved to be exceedingly wet and swampy, and most of the way across we were wading knee-deep through yielding moss or ice-cold water. It is partially wooded with small pine, spruce, aspen and tamarac, none of which have a diameter exceeding six inches. At the foot of the plateau *Anemone patens* and *A. parviflora* were found in bloom (June 6). The plateau faces westwards, with a height of 1,000 feet above the plain at its base, and is built of westerly dipping Devonian limestones. From the top of the plateau, the main range of the Rocky Mountains, which is here too far from the left bank of the river to be seen from the valley, came into sight, while in an opposite direction a good view was obtained of the rocky range which borders the river to the east. The plain between these ranges, through which the river flows, has a width of sixty or seventy miles. It shows numerous lines of wooded heights running parallel with the river, but possesses no conspicuous elevations.

The Black-
water.

The Blackwater has a width of seventy-five yards. It is the outlet of a lake situated on the further side of the range east of the river. Two miles below the Blackwater the Mackenzie makes a sudden bend of three miles to the left, below which it receives from the west a stream about a hundred yards in width, the name of which I was

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unable to obtain. The banks of the valley around the bend are about three hundred feet in height, and show boulder-clay overlying sixty feet of Saskatchewan gravels and passing upward into yellowish stratified silts.

Three miles below the bend is a section of greyish sandy shales, Cretaceous ^{section.} overlaid by soft greyish and yellowish sandstone, which I have little doubt represents the Cretaceous. The beds enclose layers and solitary nodules of ironstone, and have a thickness of three hundred feet. No fossils were obtained here, but somewhat similar beds further down the river yielded fragments of the test of an *Inoceramus*. After entering the Cretaceous basin, the proportion of sandstone and quartzite pebbles in the wash of the stream and in the banks becomes greatly increased. The Cretaceous beds here are horizontal, and have suffered much from pre-glacial denudation. Three miles below the exposure first noted, an eroded trough in their surface is filled with 140 feet of Saskatchewan gravels, topped with fifty feet of boulder clay. The Saskatchewan gravels here hold rounded quartzite pebbles from the size of a man's head downwards. These gravels in some places form two thick bands, separated by sandy beds, but in other places sand and pebble beds alternate throughout the section. Three miles farther down, Cretaceous beds are again exposed on the left bank of the river and consist here of two hundred feet of sandy shales, bluish and yellowish sandstone and ironstone. Some of the sandstone beds were coated with selenite, and crystals of the same mineral were found scattered over the surface of the section. Fragments of *Inocerami* occur in this section. The Cretaceous beds do not extend far east of the river, as limestone was found in a ridge which follows the river at a distance of about four miles. West of the river its limits were not observed, but it probably covers most of the plain which intervenes between the river and the mountains. This plain has here a width of about forty miles.

Proceeding down the river, boulder-clay and associated beds are frequently exposed, but sections of Cretaceous rocks were not again observed.

Twelve miles below the Cretaceous outcrop a large stream joins the Mackenzie from the west, which Petitot marks on his map as the Rivière du Gravois. Below it the river dilates to a couple of miles in width, and encloses some large islands. Along this part of the river a range of lofty mountains, culminating in Mount Clark, a flat topped ^{Mount Clark.} elevation from 3,000 to 4,000 feet high, runs parallel with the river on the east, at a distance of eight to ten miles; but on the west the mountains are so distant that only occasional glimpses of the highest peaks, faintly outlined against the horizon, can be obtained.

Dark boulder
clay.

For some miles below Rivière du Gravois the banks of the Mackenzie are formed of a dark plastic clay, eminently liable to slides, which at a distance resembles the Pierre shales, but on closer examination proved to be a boulder-clay. This clay in places is interstratified with beds of gravel, and for long reaches is almost destitute of boulders. It is from two to three hundred feet thick, and is overlain by stratified sandy deposits. It is underlain by the Saskatchewan gravels, small exposures of which are occasionally seen at the water level. A layer of flattened gneissic and quartzose boulders was noticed in some instances at the base of the clay. The pebbles of the Saskatchewan gravels in the neighborhood of Bear Lake River include occasional examples of a hard reddish shale, which closely resembles the rocks of the Nepigon series of the Lake Superior district, and possibly indicate the presence of a Cambrian area somewhere in the neighborhood.

Old Fort
Norman.

A few miles below the Rivière du Gravois we pass on the left the site on which Fort Norman stood at the time of Richardson's journey. The fort has since been removed to the mouth of Bear Lake River. A couple of miles below the old site, I noticed in the eastern bank a thick bed of marl, destitute of stratification and filled with fresh water shells. It lies above the boulder clay, and is now covered with a thick coating of moss. The river here and for some miles below is from two to three miles in width, and divides around an almost continuous series of alluvial islands. At this season of the year the passage of these islands in small boats is attended with some danger. The soil above the river is still frozen, while below the surface of the water it is gradually thawed out and carried away. The unsupported mass above frequently breaks off, and is precipitated into the water with a violence sufficient, in some cases, to produce huge waves, which often sweep the river with great impetuosity from side to side. On the night of the 8th of June we were awakened by a loud roar, and hurrying out could see through the gloom a white mass travelling rapidly towards us. A moment later, although we were fully fifty feet from the shore, we were standing ankle deep in water. Our boat, which fortunately was well secured, escaped uninjured, but this was entirely due to the fact that a submerged bar, a hundred yards from the shore, broke to a large extent the force of the wave. The next morning we found that a narrow strip of land, fully half a mile long, had detached itself from an island directly opposite our camp, and had fallen into the water.

Land-slides.

Opposite the islands the banks of the valley have been broken down by numerous land-slides, and rise in a succession of irregular steps. The bare clayey slopes are covered in places with saline efflorescence,

Mackenzie, which at examination were stratified e of boulders overlain by gravel, at level A noticed in Saskatchewan occasional rocks of they indicate flood left the journey. River. A bank a fresh water with a thick from two continuous usage of The soil water it ed mass ter with s, which de. On oar, and avelling fifty feet our boat, his was ls from ne next le long, and had down steps. esence,

and in this and other respects simulate so exactly the ruinous appearance of banks formed of Pierre shales, that I had to land at several points in order to assure myself that this was not the case. Pebbles and boulders are much scarcer in this clay than is usually the case with boulder clays, but a careful examination of a section usually revealed their presence in some quantities.

BEAR RIVER TERTIARY.

About twenty miles below the site of old Fort Norman, the soft clays and sands of the Bear River Tertiary beds appear in the banks. Reddish burnt shales were found along the beach some miles farther up, and indicate an extension of the basin towards the south, but the beds are hidden in this direction beneath boulder-clay slides. The first good sections met with in descending the river occur on the left bank, about twenty-four miles above the mouth of Bear River. My attention was drawn to this section by the presence in it of a conspicuous white bed, which is noticeable from the opposite side of the river. Tertiary beds are exposed here along the banks of the river for a distance of two miles. They dip up stream at the rate of about a hundred feet to the mile, and have a minimum thickness of four hundred feet. The lowest seen consist of yellowish and greyish, slightly indurated sands. The sands show cross-bedding, and hold occasional layers of pebbles. They are overlaid by thirty or forty feet of bluish and yellowish sandy shales, above which comes three to four feet of woody lignite. The lignite is succeeded by a thin bed of yellowish clay, and then by fifteen feet of a whitish-weathering arenaceous shale. This shale is very soft, and towards its base is rich in fossil leaves. The beds above the leaf shales consist of clays, sands and a couple of beds of lignite, each three to four feet thick, but they are not very well exposed. The lignite has been burnt in many places, and has hardened and reddened the enclosing shales. These baked shales when separated often exhibit beautiful impressions of leaves and fruits. The various beds are extremely irregular both in thickness and composition, and in passing along the strike, thick beds soon thin out and disappear, and clays, sands and pebbles are found to succeed one another with great rapidity. A noticeable feature of the section is the slight induration to which the various beds have been subjected. Some of the sandy layers are as loose as the sand on the bars in the present river channel, and none are hard enough to resist crushing between the fingers. In this respect and also in their lithological composition, the beds here bear a closer resemblance to the Miocene

of the Cypress Hills and Swift Current Creek plateaus than to the Laramie. The following section illustrates the alteration of the beds:—

	Feet. Inches.
1. Reddish baked shale	2 ..
2. Cream-colored baked clay	0 9
3. Greyish sand	3 ..
4. Fossil wood	1 ..
5. Yellowish clay	1 6
6. Whitish-weathering sandy shales holding fossil leaves	15 ..
7. Sulphur-yellow clay	0 2
8. Woody lignite	4 ..
9. Sandy clay	30 ..
10. Lignite	3 ..
11. False bedded yellowish and greyish sands, with layers of pebbles (lowest beds exposed)	40 ..
	100 5

Fossil leaves
and fruits.

In bed No. 6 a number of fossil leaves and fruits was collected. On my return these were placed in the hands of Sir William Dawson, and furnished the subject of a short paper which was read by him before the Royal Society of Canada, from which I extract the following:—*

POPULUS ARCTICA, *Heer*.—This is much the most abundant species in Mr. McConnell's collection, and seems to show that then, as now, this genus was dominant. This is an European, as well as an American and Greenland species, and presents a great variety in the size and forms of the leaves which has given rise to the formation of several species. Mr. McConnell's specimens show a great number of gradations in form, from a broad oval to a very broad reniform, and in size from one inch to four in diameter. Its occurrence in the Laramie of western Canada is noticed in my paper on Laramie plants (*Trans. Roy. Soc. Can.*, 1886).

There seems to be some uncertainty as to the reference of this leaf to *Populus*. Saporta thinks that it may really be a *Menospermum*, allied to the modern *M. Virginicum*. If a poplar, it is remarkable that its nearest living ally seems to be *P. Euphratica* of the banks of the Euphrates and Jordan.

POPULUS ARCTICA, *var. LATIOR*.

POPULUS HOOKERI, *Heer*.—This species, found thus far only at Mackenzie River, has small leaves resembling those of *P. Arctica* in form, but differing somewhat in venation, in which it approaches slightly to *P. tremuloides*, the common aspen.

* *Transactions of the Royal Society of Canada*, Vol. VII., Section iv., 1889.

TAXITES OLRIKI, *Heer*.—This large and beautiful Taxine plant occurs in the Eocene of Europe, and is found also in Alaska and Greenland. It is abundant in the collections of Dr. Selwyn from Souris River, described by me in the Report of the Geological Survey of Canada (1879-80). It does not seem as yet to have been recognized in the United States, and is probably a distinctively northern form. It is said by Schimper to resemble closely a species of *Cephalotaxus* found in China and Japan.

SEQUOIA LANGSDORFII, *Brongt*.—This species is very widely distributed in time and space, if all the forms referred to it are really of one species. It ranges from the Upper Cretaceous into the Miocene, and in reality is not very remote in its characters from the living *Sequoia sempervirens* of California, which may be a modern variety. It occurs in Greenland, in the Laramie of various places in the United States, and is widely distributed in Europe. Both leafy twigs and remains of cones occur in the Mackenzie collection. In the Belly River Group of Canada the species *S. Reichenbachii* replaces it, and the species referred to *S. Langsdorffii* from the Upper Cretaceous of Nanaimo, Vancouver Island appears to be *S. Smithiana*, which also occurs in the Kootanie of the Rocky Mountains. It seems therefore uncertain if in Canada it is as old as the Cretaceous, and it may in any case be regarded as specially characteristic of the Upper Laramie or Eocene flora.

PTERIS SITKENSIS, *Heer*.—This fern, not previously collected on the Mackenzie, was originally collected near Sitka in Alaska, and constitutes another link of connection between the flora of the Pacific coast and that of the interior region in the early Eocene age.

NORDENSKIÖLDIA BOREALIS, *Heer*.—This is a beautiful fruit, divided into lobes at top and supposed to be allied to Tiliaceæ. These fruits occur in Greenland and Spitzbergen and have been discovered by Mr. McConnell for the first time in Canada. It is by some referred to the genus *Cistus* or to *Diospyros*.

CARPOLITHES.—Oval, flattened bodies, probably seeds or fruits, about one centimetre in length and without distinct markings. They may be seeds possibly of *Taxites*, but their affinities for the present must remain uncertain, and I do not give them a specific name, in the hope of additional facts being discovered.

LEGUMINOSITES ? BOREALIS, *Dawson*.—Pods of unequally obovate form, apparently arranged on the side of a stem. They are grooved or ribbed longitudinally, and resemble *L. arachnoides* Lesq., except in

their smaller size and broader form. One shows what seems to be the remains of a sheath or calyx.

CALISTEMOPHYLLUM LATUM, *Dawson*.—Leaf entire, obovate, without petiole. Midrib distinct, secondary veins obsolete; indications of delicate reticulation. This is probably a Myrtaceous leaf and may, provisionally at least, be placed in the genus above named. It seems quite different from the other described species.

PYRITIZED AND FERRUGINOUS WOOD.—The collection contains several branches and portions of stems evidently of Exogenous trees, but in a state of preservation which does not admit of distinct determination. Shroeter, as already stated, has described fossil wood from these beds, one species of which, his *Sequoia Canadensis*, may be the wood of *Sequoia Langsdorffii*. Another is not improbably that of *Platanus Ungerii*. Another of his species of fossil wood is referred to the genus *Ginkgo*, but it may have belonged to *Taxites Olrikii*.

After reviewing the evidence afforded by the collections of fossil leaves and fruits which have been brought out by various explorers and examined by Heer and others, Sir William Dawson arrives at the following conclusion:—

Age of beds.
"The general conclusion indicated by the above facts is the strong resemblance of the flora of the Mackenzie River beds with that of the Laramie of other parts of Canada and the United States, and also with the Tertiary of Greenland, Spitzbergen, Alaska and the Hebrides. They thus confirm the inferences as to this similarity, and as to the Lower Eocene age of the Upper Laramie stated by the author in 'The Report on the 49th Parallel' in 1875, in subsequent 'Reports of the Geological Survey,' and in previous volumes of these Transactions."

Lignite seams
on fire.

The stratigraphical side of the question will be stated later on. On the right hand side of the river, mud slides derived from the boulder-clay conceal the underlying beds for the next five or six miles, and then the plant beds appear again, and are almost continuously exposed all the way to the mouth of Bear River. The lignite seams in this reach are on fire in several places, and have been burning since the locality was first visited by Sir Alexander Mackenzie, just a century ago. The *bocannes* are now active along the valley for five or six miles only, but reddened shales, baked by former fires, were noticed for a much greater distance. Nine miles above the mouth of Bear River a band of yellowish and greyish soft sandstone, overlain by a great thickness of unstratified clay, forms the side of the valley. A couple of miles farther down sections of the same sandstone, 125 feet

in thickness, are exposed. This sandstone is very soft, but has sufficient coherency to enable it to weather in rather steep cliffs. It is filled with pebbles, most of which are under half an inch in diameter, but it also contains some larger ones, ranging in size up to nine or ten inches in diameter. A peculiarity of the larger ones is their flattened spheroidal shape. The pebbles form small beds, running in irregular manner through the sandstone, but never extending without interruption for any great distance along the strike. They also occur scattered through the sandstone beds. The pebbles consist mostly of well rolled fragments of quartzite and hard siliceous slate. Gneissic and dioritic examples were also observed, but are not common. An *Ammonite*, probably derived from the Cretaceous beds which underlie the Tertiary farther up the river, was found in the loose conglomerate. It was changed into ironstone, and was almost structureless, but preserved its outer shape. Fragments of the stems and branches of trees fossilified to some extent by iron and frequently surrounded by a carbonized layer, are very abundant in some parts of the section. The structure of the wood in most cases is too imperfectly preserved to admit of identification. Small coal beds, an inch or so in thickness, and of limited length occur throughout the section. Resting on the sandstone and conglomerate is a layer of gneissic boulders, above which comes fifty feet of almost boulderless boulder-clay. Half a mile farther down the beds become more argillaceous, and hold several seams of lignite, from two to three feet thick, some of which are in an active state of combustion, while others are burnt out. The face of the section here was covered with debris washed down from above, and no accurate measurement of the beds was possible. The most interesting part of this section was under water at the time of my visit, and can only be examined in the autumn. The plant bed from which Richardson obtained his specimens was entirely covered, and this was also the case with the nine foot seam of lignite which he mentions. The edible clay bed referred to by him was just visible below the surface of the water, and a specimen was dug up with the paddle. This clay is of a light yellowish color, and is highly plastic. It is used for whitewashing purposes, and in former times served the Indians as a substitute for soap.

Tertiary beds, similar in character to those just described, extend along the Mackenzie almost to the foot of Bear Mountain. They are then replaced on the right bank of the river, for some miles, by the limestones and shales of the Devonian, but reappear again twelve miles below the mouth of Bear River, and are exposed along the valley for about half a mile, when they finally disappear. At this

*Thickness
of beds.*

point they dip down stream at an angle of fifteen degrees, which would give them a minimum thickness of 600 feet. On the left bank the limestone interruption does not occur, and the section is more continuous.

*Distribution of
Tertiary beds.*

The Bear River Tertiary basin, measured along the Mackenzie, has a length of about forty miles. Its width was not ascertained, but Tertiary beds probably underlie the flat country which borders Bear River for twenty miles above its mouth. They cannot extend more than fifteen or twenty miles in a westerly direction, as a lofty limestone range runs parallel with the river at about that distance. The distribution of the beds is thus limited to an area forty or fifty miles in length, and thirty or forty in width, and may be considerably less.

*Age of Ter-
tiary beds.*

The beds of this Tertiary basin are evidently lacustral in their origin, and both in lithological character and stratigraphical position have a much closer resemblance to the Miocene (White River) of the Cypress Hills and neighboring areas than to the Laramie with which their fossil flora correlates them. Like the Cypress Hills beds they are characterized by their irregular deposition, by their slight induration and by the large proportion of gravel and pebble beds which they contain, and a further degree of relationship is evidenced by the fact that they both rest unconformably on the beds beneath. Mere lithological similarity in the case of two such widely separated detrital terranes is of very little value in determining age, and in the present instance might be disregarded, were it not supported by the more important feature of a corresponding structural break. In the area of the Great Plains, and even in the Rocky Mountains, the Laramie is everywhere conformable to the Cretaceous beds below, but sustains a discordant relation to the overlying Tertiaries, and it has been found that its termination was synchronous with a widespread elevation of the land and the formation of fresh water lakes, in which the succeeding deposits were laid down. At the mouth of Bear River, instead of a conformable passage from the Cretaceous to the Tertiary, we have evidence that the former was elevated and subjected to a prolonged denudation before the latter was deposited. In order to reconcile the stratigraphical position of the Bear River beds with a Laramie age, it will therefore be necessary to assume that this part of the continent was, towards the end of the Cretaceous period, affected by extensive movements of elevation and depression in which the central part did not participate.

I was delayed a couple of days at Fort Norman, and while there ascended Bear Rock. This elevation is situated in the angle formed by the junction of Bear River with the Mackenzie, and runs in a north-easterly direction for three or four miles, with a width of about a mile. It was found to have a height of 1,400 feet. From its summit an extensive view over the surrounding country was obtained. The Mackenzie valley here presents the same general features which have characterized it since leaving the great bend. It cuts through a forested plain fifty to sixty miles in width, which is broken by low plateaus and hills, and rimmed in on either side by lofty limestone ranges still wrapped in their winter covering. To the southeast, Mount Clark, forty to fifty miles away, formed the background to a lake-dotted and forest-clad plain which swept up to its base. From the northern shoulder of this mountain a line of lower elevations extended to Bear River, and crossing it continued in a northerly direction beyond the range of sight. Bear River lying almost at our feet, and making a great curve to the left could be traced winding through an almost level plain until it entered and was lost in the wide gap which it has cut through the range detached from Mount Clark. Looking across the river in a south-westerly direction the view was bounded at a distance of twenty-five or thirty miles by an irregular range of limestone peaks and ridges which ran north-west and south-east as far as the eye could reach. A number of streams descending from the mountains united to form a considerable river which, after a short course, empties into the Mackenzie a few miles below Bear River. I was somewhat surprised at the extent and apparent thickness of the snow fields, which still covered the flanks and summits of the higher elevations, but on enquiry was informed that they all disappear before the end of the summer.

Bear Rock is separated from the main range, and is built of limestones, quartzites and shales, bent into the form of an anticlinal. A small stream cuts deeply into the heart of the mountain and exposes a very good section. The lowest beds seen consist of reddish and greenish shales, alternating with layers of pink colored gypsum, and cut by numerous veins and seams of a white fibrous variety of the same mineral. The gypsum in parts of the section replaces the shales almost altogether, and the layers are separated by mere films of greenish and reddish argilaceous material. The base of the gypsiferous shales was not seen, but they are at least several hundred feet in thickness. They are overlain by a series of dolomites, quartzites and limestones six to seven hundred feet thick, and then by the bluish coral bearing limestones of the Devonian. Some of the limestone is bituminous, and emits a fetid odor when struck, and Franklin states

that he saw* "sulphureous springs and streams of mineral pitch issuing from the lower parts of the limestone strata." These were not seen by Richardson when he descended the river in 1826, on account of the height of the water, and they were also hidden at the time of my visit.

FORT NORMAN TO FORT GOOD HOPE.

Leave Fort
Norman.

We left Fort Norman on the 12th of June, and crossing the clear, cold water of Bear River paddled along the base of Bear Rock and continued our way down the Mackenzie. At this date the trees were still leafless, but the various species of willows and birches had hung out their catkins, and the early flowering anemones, accompanied by *Hedysarum boreale*, *Lupinus arcticus*, *Potentilla nivea* and others, brightened the valley with color. Blocks of ice, accumulated in places into cliffs, still lined the shores, but were fast disappearing.

Mackenzie
below Fort
Norman.

From the mouth of Bear River the Mackenzie runs in a general west-north-westerly direction for eighty miles to Roche Careajou, and then turns due west towards the East and West Mountains of the rapid. In this distance it has an average width of over a mile, and occasionally expands around islands to over ten miles in width. Its current is at the rate of three or four miles an hour. Rugged limestone ranges are visible all along this reach on both sides of the river, but seldom approach within thirty miles of each other. The plains between and lower slopes of the mountain are continuously clothed with forests of small spruce and aspen. The depression in which the river flows has a depth of from one to four hundred feet and a width of from two to three miles. River flats are seldom present, and the banks of the valley slope more or less steeply up from the edge of the water.

Age of uplift.

Below Bear River, as stated before, the Bear River Tertiary beds are exposed in the banks of the valley for a mile or more, and are then replaced by Devonian limestones brought up by the Bear Mountain anticlinal. This uplift must have been produced, at least partially, in post-Tertiary times, as it has affected the plant beds to some extent. In their reappearance some distance farther down they are found dipping down the river, or away from the north-western limb of the anticlinal, while in the upper part of the basin they dip at a small angle in the opposite direction.

Twelve miles below the mouth of the river we cross the north-western boundary of the Tertiary basin, and three miles farther on

* See Appendix to Franklin's second journey.

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Devonian shales are exposed in the banks on the left-hand side of the river. These shales are horizontal, and are overlain by some soft shales, sandstone and nodular beds holding fossil oysters, which are probably of Cretaceous age. In the next twenty-five miles small sections of bluish shale, shaly sandstones and limestones, holding Devonian fossils, are exposed at intervals. Farther down this series sinks below the surface, and is succeeded by post-Tertiary sands, gravels and shales, which resemble in appearance the Tertiary beds at the mouth of Bear River, but are distinguished from them by holding fragments of lignite, which are evidently derived from the latter. They are overlain by soft marly beds, holding recent fresh-water shells. The river here is over two miles wide, but is obstructed by numerous islands and bars. In the next interval of ten miles there are no exposures, and then scarped banks appear again. Here the rocks consist of rusty, reddish-weathering shales, interstratified with small beds of sandstone and ironstone, and holding fragments of *Inocerami* of Cretaceous age. These rocks are very similar to the Cretaceous beds found above the Bear River Tertiary area, and probably represent a part of the same basin cut off by denudation.

Below this exposure the beach is shelving, and at the time of our visit was covered with great blocks of ice, piled up so as to form a vertical cliff facing the river twenty to thirty feet high, and extending in an unbroken line for miles. While passing along this a strong gale sprang up, blowing directly across the river, which is here over a mile and-a-half wide, and placed us in a position of some danger. The ice cliffs, from which great blocks were constantly falling, prevented us from landing, while the waves, becoming momentarily larger, threatened to swamp our overloaded boat, and we were only kept afloat by incessant bailing. The severity of the gale rendered any attempt to gain the opposite shore hopeless, and our only chance of safety lay in finding, and that speedily, a break in the ice wall, which stretched out apparently interminably before us. Fortunately for us, such a break, formed by a small side stream which had cut its way through the icy embankment, was soon reached. These ice cliffs are the remains of ice dams formed when the river is breaking up in the spring. When the dam is forced by the pressure of the water behind, the central part floats away, but the masses which have been shoved up on the shore remain there until melted by the sun.

Near the mouth of the river at which we landed, is a small cliff formed of a yellowish-weathering coralline limestone. Some of the beds are brecciated, and the appearance of the whole section is remarkably like that seen at the mouth of Buffalo River on Great Slave Lake. Three

Coralline
limestone.

Cretaceous shales.

Roche Carcajou.

Glacial striae.

View from Roche Carcajou.

River below Roche Carcajou.

Cretaceous shales.

East Mountain of rapid.

miles below this section the river widens out, and shortly afterwards Cretaceous shales appear in the bank, and are then continuously exposed all the way to Roche Carcajou, a distance of over fifteen miles. The shales are dark in color, and enclose numerous nodules and nodular beds of ironstone. Some of the nodules when broken afforded specimens of *Ammonites* and *Inocerami*.

Roche Carcajou* rises about a thousand feet above the river, and is formed by an uplift of the Devonian limestones. On the south-western side of the anticline the beds plunge steeply down towards the river, but to the north-east the dip is much easier. Cretaceous beds rest on the flanks of the hill, and on the opposite side of the river the banks of the valley exhibit the dark shales and bluish sandstones of the same formation.

Well marked glacial striae were observed crossing the summit of Roche Carcajou, and striking about fifteen degrees north of west, or nearly in the direction of this portion of the valley of the Mackenzie.

North-eastwards from Roche Carcajou, the mountains appear to be broken into a series of short ranges, none of which attain any considerable elevation, but to the south-west a well defined range of rugged peaks can be traced stretching away in a north-westerly direction until they sink below the horizon. This great range, broken at intervals by outflowing streams, has been followed from near Fort Liard on the Liard River, a distance measured in a straight line of nearly five hundred miles. Below this point the river bends away to the north, and the range is not seen again until Peel River is reached.

From Roche Carcajou, the Mackenzie runs almost due west for fifteen miles to the East and West Mountains of the rapid, and then bends more to the north before falling over the Sans Sault Rapid. In the upper part of this reach it is somewhat contracted, but before reaching the mountains it expands considerably, and is split up into several channels by islands. Between the two mountains it contracts again, and continues somewhat narrow as far as the rapid.

The banks of the valley below Roche Carcajou show numerous exposures of the shales and sandstones of the Cretaceous, holding fossiliferous ironstone nodules. At the expansion referred to above the Cretaceous beds are overlaid by post-Tertiary sands.

The East Mountain of the rapid, like Roche Carcajou, Bear Mountain, and numerous other elevations in the Mackenzie valley, represents an anticlinal uplift of the Devonian limestone. The West Mountain of the rapid is situated at some distance from the river, and was

* So called from the fancied resemblance of a weathered knob of rock which stands prominently out from the face of the hill, to the animal of this name.

not closely examined, but as far as could be seen it is of the same nature. At the East Mountain the limestones come down to the river, and are exposed along the shelving shore of the eastern bank for some distance. On the opposite side, the banks when scraped show the shales, sandstones and ironstones of the Cretaceous. The two formations appear to be conformable or nearly so, and have been folded by the same movements.

The Sans Sault Rapid is the most important obstruction to the navigation of the Mackenzie from Great Slave Lake to the sea. In high water the rapid is almost drowned out, and little difficulty is experienced by the steamer *Wrigley* in ascending it, but in low water the fall is greatly increased, and is sufficient to prevent ordinary navigation. Part way down the rapid the river is divided into two channels by an island. The western channel, which we descended, presented at the existing stage of water, nothing beyond an accelerated current. The eastern channel appeared more formidable, and the numerous spots of white water spoke forcibly of sunken rocks and other obstructions.

Cretaceous rocks, undulating at low angles, are well exposed on the left bank all along the rapid. As elsewhere they consist of dark shales and sandstones, alternating with some nodular ironstone beds. The latter are sparingly fossiliferous, and yielded an *Inoceramus*, a fragment of an *Ammonite*, a *Camponectes*, a small *Trigonia* and some other lamellibranch and gasteropod shells, too fragmentary to admit of even generic determination. Five miles below the Sans Sault Rapid, on the right bank, is an exposure of whitish and yellowish sandstone, the age of which is uncertain, overlain by the shales, sandstones and ironstones of the Cretaceous. Some of the beds of sandstone are conglomeritic, and hold pebbles of quartzite and slate, while others enclose fragments of carbonized vegetable remains. Three miles farther down Devonian limestones appear again, and form a projection called Beavertail Point. The limestones are filled with corals, and dip in a westerly direction at an angle of about 15°.

From Beavertail Point to the Ramparts, a distance of about twenty-five miles, the river is very much expanded, and has an average width of nearly two miles. The banks are generally low, and are principally built of post-Tertiary sands, clays and gravels; but Cretaceous shales and ironstones were also observed at one or two points.

THE RAMPARTS.

The Ramparts form one of the most interesting features of the Mackenzie. For some distance above, the river is expanded beyond its

usual size, but here suddenly contracts to about five hundred yards in width, and bending to the east runs for three or four miles between vertical walls of limestone and shale. At the upper end of the gorge the bounding cliffs are a hundred and twenty-five feet in height, but increase towards the lower end to about two hundred and fifty feet. The current is steady and runs at the rate of four or five miles an hour. In high water there is no sign of a rapid, but in low water a considerable fall occurs near the head, and it is only with difficulty that York boats are taken up. The caves and turreted rocks mentioned by Franklin* were not seen by me, and were probably covered by the high water. The Ramparts are frequently the scene of great ice jams in the spring, and the dammed-back water is stated to have risen on one occasion, over a hundred feet, and on its recession left a boat stranded on the heights above.

*Current in
Ramparts.*

*Geology of
Ramparts.*

Above the Ramparts Cretaceous shales and ironstones are exposed for a couple of miles, dipping at a low angle up the river, but the actual contact of these with the limestones was not seen. At the head of the ramparts Devonian limestones rise from beneath the Cretaceous, and it is through these that the cañon is cut. The limestone undulates at low angles, but also rises steadily in the walls of the cañon as we descend, at the rate of about fifty feet to the mile. In the upper part of the cañon the walls are precipitous, and consist of limestone throughout. The limestones are generally granular in texture and weather to a light cream colour. Some of the upper beds are brecciated and lower down in the band a large proportion of the mass of the rock consists of various species of corals. Thin beds of shale attenuated to mere films in some instances, are interstratified with the limestone, and increase in importance towards the base. This band of limestone has a thickness of between 150 and 200 feet. Part way down the cañon bluish green shales holding beds of limestone at intervals, appear below the limestone band, and increasing gradually in height form the basal part of the walls of the cañon the rest of the way. The banks here weather into a steep slope below, but are crowned with almost vertical cliffs above. These shales are precisely similar to those found in the Liard on Hay River, and underlie a similar limestone. The fossil evidence demonstrates that they occupy the same horizon in the Devonian series. This close resemblance is somewhat remarkable when we bear in mind that the two localities are separated by a distance of five hundred and seventy miles.

Fossils.

The shales and interstratified limestones are filled with corals, brachiopods and other fossils which weather out of the soft rocks in almost

* Second Journey, p. 22.

perfect condition. A large collection was made in the couple of hours which I devoted to this purpose, from among which the following forms have been identified by Mr. Whiteaves:—

- Cyathophyllum arcticum*, Meek.
- Aulophyllum Richardsoni*, Meek.
- Cystiphylloides Americanum* var. *arcticum*, Meek.
- Pachypora cervicornis*, De Blainville.
- Alveolites vallorum*, Meek.
- Spirorbis omphalodes*, Goldfuss.
- Cornulites (Ortonia) sublavis*, Whiteaves.
- Hederella Canadensis*, Nicholson.
- Paleschara quadrangularis*, Nicholson.
- Chonetes Logani* var. *Aurora*, Hall.
- Productella lachrymosa* var. *lima*, Conrad.
- Orthis striatula*, Schlotheim (= *O. Townensis*, Hall.)
- Spirifera glabra*, var. *Franklini*, Meek.
- Cyrtina Hamiltonensis*, Hall.
- Atrypa reticularis*, Linnaeus.
- Atrypa reticularis* var. *aspera*, Schlotheim.
- Rhynchonella pugnus*, Martin.
- Rhynchonella castanea*, Meek.
- Pentamerus galeatus*, Dalman.
- Stringocephalus Burtini*, Defrance.
- Cryptonella Calvini*, Hall and Whitfield.
- Ressellaria levis*, Meek, not Hall.
- Paracyclas elliptica*, Hall.
- Straparollus flexistriatus*, Whiteaves.

FORT GOOD HOPE.

This fort is situated a short distance below the Ramparts and is the lowest fort on the Mackenzie. It was originally built over one hundred miles lower down, and has been moved several times before the present site was finally selected. It is situated only a few miles south of the Arctic circle, but this does not prevent some gardening from being attempted. Potatoes, turnips and other garden vegetables are raised in some quantity, and even barley has occasionally been ripened, although the ground is permanently frozen three or four feet from the surface. Cattle and poultry are kept at the fort, but the former have to be fed over seven months in the year.

I remained at Good Hope a day, and while there ascended a neighbouring hill about three hundred feet high, which promised to afford a

Gardening at
Fort Good Hope

View from hill. view of the surrounding country. From the summit a low ridge running northwards from the Ramparts was noticed, and farther on several peaks in the direction of the Sans Sault Rapid came into view. The range west of the river had completely disappeared, and a tree-covered plain extends to the horizon. Innumerable muskegs and lakes of all sizes could be seen in every direction, and here and there bright patches of yellowish reindeer moss relieved the monotony of the landscape.

Flowering plants.

In returning from the hill a number of early flowering plants were collected, among others *Anemone patens*, *A. parviflora*, *A. Richardsoni*, *Draba incana* var. *confusa*, *Potentilla nivea*, *Petasites frigidus* and *Plantago maritima*. The birch (*Betula papyrifera*) the willows *Salix rostrata*, *S. glauca*, *S. speciosa*, the red current *Ribes rubrum*, and other shrubs were in bloom (June 17), but the general forest still remained leafless.

FORT GOOD HOPE TO THE MOUTH OF PEEL RIVER.

Hareskin River.

Rocks in valley below the Ramparts.

We left Good Hope on the 18th, and continued our journey. Three miles below the fort we passed the mouth of Hareskin River on the right. This stream heads near Great Bear Lake, and was explored by Macfarlane in 1857, on his return from the Anderson River.* Opposite the mouth of the Hareskin the Mackenzie is a mile and a half wide, and has a current of three miles an hour. Three miles below the Hareskin River, Devonian shales are exposed on the right bank. Here they are overlain by the Saskatchewan gravels, on top of which rests the boulder-clay, but two miles farther down the gravels disappear, and the boulder-clay comes directly in contact with the shales. Five miles below, on the opposite side of the river, the shales which are evidently the same as those found at the Ramparts, are overlain by yellowish limestone. In the next twenty-five miles, or as far as the Grand View, Devonian shales overlain occasionally by yellowish-weathering fossiliferous limestones, are exposed at intervals all along. The left bank of the river on this reach is usually low and sloping, but the right is bounded for some miles by high limestone cliffs similar to those at the Ramparts. At the head of the Grand View the cliffs leave the river and bend more to the north. Richardson states that the upper portion of the cliffs consists of sandstones and shales, which, from his description, evidently belong to the Cretaceous. Where I examined them limestone alone was seen, but it is possible that this may be capped in places by outliers of the Cretaceous rocks which rest on the Devonian limestones above the Ramparts.

* Canadian Record of Science, January, 1890.

The "Grand View" is a name given to an expanded portion of the Mackenzie, about twenty miles in length. The river here is almost straight, but curves gently to the north, and is from two to three miles wide. Its great width gives it more the appearance of a lake than a river, and in no other part of the Mackenzie is the magnitude of the mighty volume of water which this river carries to the sea impressed so forcibly on the mind. The banks are low and the sinuous shore-lines show a succession of wooded points stretching out until concealed by the haze of the atmosphere. The bordering plains slope gently down almost to the water's edge, and are covered with a scattered growth of willow, spruce and tamarac, with here and there patches of aspens on the drier ridges. The spruce along part of this reach presents a remarkably stunted and dwarfish appearance, but this is due more to the marshy character of the ground than to climatic severity, as the same tree, straight and well grown, was found much further north. Very little change in the character of the forest was observed in descending the Mackenzie, and with the exception of the banksian pine, (*Pinus Banksiana*) which disappears south of Bear River, the same species, as previously noticed by Richardson, are found from Great Slave Lake to the mouth of Peel River.

The rocks exposed along the Grand View consist of dark argillaceous shales, some of which are bituminous, and dark greyish sandy shales. Both varieties are fissile and split easily into large thin plates. The sections are small and the shale outcrops only along the water's edge. It is much harder than the shales at the Ramparts, but evidently belongs to the same horizon. Some fossils were collected here, among which are *Atrypa reticularis*, *L. A. aspera*, *Schloth. Productella spinulicosta*, Hall, and a *Proetus*, probably identical with *P. Haldemani*, Hall.

Fifteen miles below the Grand View my attention was attracted by a small plateau situated some distance east of the river, the face of which showed red patches somewhat similar to those occurring in the burnt Tertiary shales at the mouth of Bear River and other places. No sections had been seen for some miles above, and as I was apprehensive of some new formation appearing which might not be exposed in the valley I decided on visiting it. Two hours of extremely difficult walking through tangled willows and small spruce, alternating with flooded muskegs, brought me to the foot of the plateau. It proved to be formed of Devonian shales, associated with some sandstone and shaly limestones, from which I obtained specimens of the ubiquitous *Atrypa reticularis*, and of a few other forms which have not been determined. No lignitic or coaly seams were observed, the burning of which might color the associated rocks, but the shales were found to

Rocks at the
Grand View.

Burnt shales. be highly charged with bitumen, and the red coloration is undoubtedly due to the combustion of this mineral. The fires have not been very intense, as the shales are only reddened on the surface, and are not baked and vitrified like those found near the burnt lignite seams at the mouth of Bear River. Some combustion is evidently going on at the present time, as a distinct bituminous odour was detected near the hill, but no flames or smoke were visible.

Bituminous shales.

Eight miles below the plateau just described, stratified sands of the age of the Saskatchewan gravels, overlain by boulder-clay, are exposed in the right bank, and seven miles farther on Devonian shales are again found. The shales here are black in color, evenly bedded and highly bituminous. The laminae, when freshly separated, are moistened on the surface with an oily liquid, and burn when thrown into the fire, and patches of red shales, marking the sites of former fires, alternate with the dark varieties. The shales are exposed in the right bank for some miles, or almost as far as old Fort Good Hope. They dip down the river at a low angle, and are overlain by the Saskatchewan gravels and boulder-clay.

Saskatchewan gravels.

The material of the Saskatchewan gravels here, while mainly quartizitic, includes also a considerable quantity of gneissic and dioritic pebbles of Archean origin, the proportion of which seems to increase as we descend the river. In addition to these, large angular masses of the shales and limestone of the underlying Devonian are frequently present, and also small beds and disseminated particles and blocks of lignite derived from the Tertiary. The beds of this terrane are seldom consolidated to any extent, either by pressure or by a cementing agent, and the sands and gravels of which it consists succeed one another in an extremely irregular manner, and when not too coarse almost invariably exhibit cross-bedding and other evidences of rapid deposition.

Character of Mackenzie.

From old Fort Good Hope the Mackenzie bends to the west, and maintains a general westerly course for the next fifty or sixty miles, or almost to the mouth of Red River. In this reach the river has a width of a mile to a mile and-a-half, and a current of from two to three miles an hour. It is bordered by wooded plains, and no mountains are visible on either side, although low escarpments appear at various points. Groves of white spruce were seen along this reach, containing trees measuring over fifteen inches in diameter, but the average tree does not exceed six inches.

Above old Fort Good Hope the Devonian shales dip below the surface of the river and were not seen again, and the valley for some distance shows only the boulder-clay and associated sands and gravel

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deposits. The boulder-clay is somewhat plastic in places, and shows Rocks near old Fort Good Hope the same disposition towards landslides which characterized it above the mouth of Bear River. The valley here is about two hundred feet deep, and its banks, when not broken up by slides, present remarkably even slopes, on which I found growing in some abundance the familiar sage bush of the plains, *Artemisia frigida*, along with the juniper and various grasses.

Twenty miles below old Fort Good Hope, shales were observed Re-appearance of Cretaceous shales. on the right bank, which are plainly different from those occurring farther up the river. They are dark greyish in colour, and rather soft, but enclose some harder beds, and pass in places into a shaly sandstone. Some ironstone is also present. No determinable fossils were found here, but the surface of some of the beds is covered in places with fragments of leaves and small carbonized stems of plants. I was at first somewhat doubtful in regard to the horizon of these shales, but evidence obtained afterwards proved them to belong to the Cretaceous. Resting on the shales at this point is a layer of large Archæan boulders, well worn and flattened, above which comes the Saskatchewan sands and gravels. In the next fifteen miles the shales are exposed at a number of points, but proved to be remarkably destitute of fossils. A careful search was made at several favorable looking localities, but nothing was obtained except an almost unrecognizable fragment of an ammonite, which was found at the base of one of the sections.

Below the sections just referred to, an interval of fifteen or twenty miles occurs, in which the banks show only boulder-clay, underlain by Saskatchewan gravels, and then the shales reappear, and are exposed for many miles below. They are harder here than when first seen, and weather into steep cliffs, which line both banks of the valley, and for some miles form a kind of wide cañon, which has received the name of the Lower Ramparts or the Narrows.

At these Ramparts the valley makes a sudden horse-shoe-shaped Low'r Ramparts. bend to the north of ten or twelve miles in length. The river is over half a mile wide at the narrowest point, and for most of the distance exceeds a mile in width. There is no sign of a rapid, and the current has nowhere a rate of over five miles an hour.

The Cretaceous rocks at the Lower Ramparts are horizontal, and consist of dark greyish shales passing into a shaly sandstone, along with more heavily bedded bluish sandstones. The rocks are all somewhat ferruginous and weather to a rusty color. About two hundred feet is exposed. The sandstone holds numerous coaly particles disseminated irregularly through the beds, and in one or two instances by the addition of whitish quartz pebbles, was observed to pass into a fine grained

Rocks at Lower Ramparts.

conglomerate. The surfaces of some of the beds are covered with a network of the impressions of narrow leaved plants, but nothing determinable was obtained.

Franklin mentioned the occurrence of limestone in the cliffs at the Narrows, but this, if present, must have been concealed by the high water when I passed through, as it was not noticed.

Loucheux Indians.

Character of crew.

Reach head of delta.

Character of forest.

Immediately below the Narrows we passed on the left the mouth of Red River, and seven miles farther down came to a large encampment of Loucheux. These Indians have evidently encroached somewhat on the territory of the Eskimo since the days of the early travellers, as Richardson describes the Lower Ramparts as being the boundary at that time. The Loucheux have now a church north of that point, and have undisputed possession of the river as far as Point Separation. I remained over night at the Indian encampment, and before leaving in the morning engaged one of the Loucheux to accompany us in the capacity of interpreter, in case we should fall in with the Eskimo. The Loucheux are on friendly terms with the Eskimo, and most of them can speak the Eskimo language. My crew was now a somewhat heterogenous one, and consisted of a Slave Indian from Fort Simpson, a Hare Indian from Fort Good Hope, and a Loucheux from the mouth of Red River. In order to communicate with the latter I had first to speak to the Fort Simpson Indian, who understood a little English, and he passed it on with some difficulty to the Good Hope Indian, who in turn interpreted it in a more or less changed form to the Loucheux, and the answer was then returned in the same cumbersome manner. The dialects of the various Tinneh tribes scattered along the Mackenzie differ very markedly, and the Indians from the upper part of the river have considerable trouble in making themselves understood by those at the lower posts.

Ten miles below the Indian encampment we came to what may be considered the head of the delta of the Mackenzie. The Cretaceous shales and sandstones have disappeared, and the banks, now composed of alluvial sands and clays, have decreased in height to fifteen or twenty feet, while the river, which at once opens out to more than ten times its former width, completes its journey to the sea through a network of interlacing channels.

From the head of the enlargement we took the left hand channel and followed it for ten or twelve miles to the mouth of Peel River. The coast here is low and sandy, and is exposed to the full rigour of the arctic storms, and the general vegetation of the bordering plains is stunted and diminutive in appearance, but is relieved by the presence of a few large spruce trees, which look like survivors from an ancient

and more luxuriant forest. Some of these trees have a girth of over six feet, and are tall and well shaped, while the average spruce in this latitude does not exceed six or seven inches in diameter.

Before reaching Peel River we fell in with a small band of Eskimo ^{Fall in with Eskimos.} who were on their way to Fort Macpherson to make their spring trade. We had been warned that they would probably prove troublesome if we met them returning from the fort, and were, therefore, somewhat relieved to find that the backwardness of the spring had prevented them from ascending the Mackenzie as soon as usual, and that they had not visited the fort yet, and were consequently still on their good behaviour. As soon as we came abreast of the encampment a small fleet of kyaks were launched and we were soon surrounded by all the males of the party, but beyond a general demand for tobacco they did not offer to molest us in any way.

The Mackenzie River Eskimos, or a part of them at least, spend a few ^{Notes on the Eskimos.} days every spring trading at Fort Macpherson, but with this exception, and the chance meeting with a few travellers, have had little intercourse with white men, and have not been affected by them to any noticeable extent. The forbidding and inhospitable character of the country they inhabit, has not prevented missionaries from endeavouring on one or two occasions to establish themselves among them, but the efforts of these have, up to the present, met with little success. The Mackenzie River Eskimos, unlike their Indian neighbours, do not buy clothing from the traders, and still dress in sealskins, trimmed when possible with the fur of the carejou, in the manner described by the early travellers. Labrets are still worn in the cheeks, and long, broad bladed knives of their own manufacture carried on all occasions naked in the hands. Bows and arrows are still their principal weapons, but are gradually being replaced by rifles and revolvers obtained in trade to the west, from whalers.

PEEL RIVER.

We entered Peel River shortly after noon on the 23rd of June, and ascended it the same day for eight or ten miles. Towards evening, when preparing to camp, we were somewhat surprised to see a Peterborough canoe shoot around a bend in the stream ahead and rapidly approach us. A moment afterwards we were hailed by a member of Mr. Ogilvie's party, and had the pleasure of learning that that explorer was just behind. He appeared in a second canoe in a few minutes, and the next day being Sunday we decided to allow ourselves a holiday to spend it together. Ogilvie was jubilant at the successful completion of his arduous journey across the mountains, and was congratul-

<sup>Enter Peel
River.</sup>

lating himself that the hardest part of his journey was over, but his description of the rapid current of the Yukon, and the difficulties attending its ascent did not serve to raise my spirits.

We separated on the 25th, and I continued on up the Peel, and arrived at Fort Macpherson the same afternoon.

Peel River splits up before joining the Mackenzie, and enters the latter through several channels. Ten miles above its mouth the various streams unite, and from this on, as far as the fort, it preserves an

Current of Peel River.

Rocks on Peel River.

average width of four or five hundred yards. The current at the time of my visit ran at the rate of four miles an hour. The banks and bordering plains are low, and are formed of alluvial sands and clays. No older rocks were seen until the bluff on which the fort is built was reached. Here shales are exposed which are evidently of Cretaceous age, although no fossils were found. These shales are dark in colour, rather soft, and crumble away under the influence of the weather into a steep talus of small glistening flakes. Scattered through them are numerous small pebble-like concretions of ironstone. The shales are surrounded on all sides by alluvial deposits, and must have formed an island in the sheet of water in which the latter was laid down.

Exploration of Peel River.

Peel River, above Fort Macpherson, was explored in 1839 by Mr. Bell, clerk in the employ of the Hudson's Bay Company, and a description of his trip is given in the proceedings of the Royal Geographical Society,* by Mr. Isbister. According to this account the river winds along the base of the mountain through a low alluvial country for thirty miles above the fort. A rapid was then encountered, caused "by a contraction of the banks of the river which here begins to flow over a hard pebbly bottom." Above the rapid the current becomes much swifter, and the river seems gradually to approach the mountains and soon afterwards to enter them. "The banks of the river had now entirely changed their aspect, and instead of through the low, unvarying mud cliffs, with the sombre and cheerless appearance which the recent deposit of alluvium had imparted to them, the water course was not unfrequently through bold romantic defiles, so steep and lofty as often to hide the mid-day sun from view." Mr. Bell ascended the river with boat and canoe as far as it could be navigated, and then continued on up it on foot, until it had dwindled down to an insignificant stream, fifteen or twenty yards in width. The two main feeders he named the Simpson and Macpherson rivers. Peel River has a length of about three hundred miles, and its course is almost parallel to that of the Mackenzie. It is the largest river which empties into the Mackenzie north of the Liard.

* Journal of the Royal Geographical Society, Vol. XV., 1845, p. 332.

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An interesting result of the explorations of Mr. Bell, is the proof it affords of the continuity of the Rocky Mountains northwards. This range is lost sight of in descending the Mackenzie near the Sans Sault Rapid, and is not seen again until the traveller emerges from the Lower Ramparts, a distance of over three hundred miles, and it has been stated by some geographers that it bends to the west and follows an easterly course through the centre of Alaska. There is little doubt, however, that with the exception of the gap through which the Liard flows this range is continuous from the International Boundary to the shores of the Arctic ocean.

RAT RIVER.

Fort Macpherson was reached on the 25th of June, and as the Mackenzie steamer from which I expected to obtain supplies was not expected down until the 10th of July, a short trip was made up Rat River while awaiting its arrival. At the fort I was informed that neither boats nor canoes could be obtained west of the mountains, but that the boat I had used on the Mackenzie might be portaged across by taking it up Rat River and then through the MacDougal pass to Bell River on the other side. This plan was adopted, and five Indians were sent to try to take it across. They made the portage in seven days.

Rat River is represented in Isbister's map of Peel River, published in 1845, in the journal of the Royal Geographical Society, as rising on the western side of the Rocky Mountains and flowing directly across them. This error was probably caused by the same name being used by the Indians to designate the two streams flowing east and west from the summit of the range. Rat River (east) discharges its waters by two mouths. The north branch empties into one of the delta streams of the Mackenzie, and has not yet been explored, while the south branch joins Peel River about nine miles below Fort Macpherson. When Peel River is in flood the current in the south branch is reversed.

Rat River for some miles above its mouth, winds through a flat alluvial plain, forming part of the Peel-Mackenzie delta. Its width is about fifty yards, and the current is uniform and easy. Above this reach it enters a lake region, and for several miles connects by short channels a number of small irregular-shaped willow-fringed lakes lying in shallow depressions in the delta. West of the lake region the declivity of the stream rapidly increases, and a few hours hard paddling brought us to the foot of a series of strong rapids which mark the beginning of the ascent towards the mountains. Leaving our canoe here we tramped eight miles across a marshy plain to the foot of the first range, our objective point. For part of the way we travelled along

Reach Fort
Macpherson.

Leave canoe.

the top of a low narrow ridge, which is probably of morainic origin, and is composed, so far as I could learn from the surface, of quartzite pebbles and boulders carried eastwards from the mountains.

Geology of eastern range of Rockies.

The eastern range of the Rockies where broken through by Rat River, has a nearly north and south trend, and rises to an elevation of about 2,800 feet. It is built throughout of evenly bedded hard sandstones and quartzites, dipping to the east at an angle of about 30°. No fossils were found in rocks *in situ*, but in the wash of Long-stick Creek, a tributary of Rat River, which descends from the same range and was crossed on the way, *Ammonites* and other fossils of Cretaceous age were found. These occur in angular sandstone blocks, evidently derived from the neighbouring mountains, and I have little doubt characterize the formation of which the latter are composed. No limestones, gneisses or granites, were observed.

A sub-angular gneissic boulder, representing the eastern drift, was found on the eastern slope of the mountains at a height of 1,500 feet.

PEEL RIVER PORTAGE.

On July 10th I decided not to waste any more time waiting for the steamer, as it was impossible to tell how long it might be delayed, and to trust to the chance of finding supplies at Rampart House. I had sent part of my outfit across by some Indians who were returning to Lapierre House, and Mr. Hodgson, after some trouble, succeeded in engaging five others to accompany me and to carry the remainder. The ordinary load for an Indian on this portage is forty pounds, exclusive of blanket and supplies for the trip, and the tariff for this load is fifteen skins, or seven dollars and a-half, paid in goods. The portage is about sixty miles long, and from four to five days are occupied in the trip.

Indian packers.
Leave Fort Macpherson.

Terraces at base of mountains.

We left the fort late in the afternoon, and ascending the river for a mile and a-half, landed on the opposite side and strapped on our packs, while some dogs owned by the Indians were loaded so heavily that they were unable to climb the bank of the river and had to be assisted up. After leaving the river we marched for three miles through a thick spruce forest, and then reached the steep edge of a terrace about one hundred and fifty feet high, up which we climbed. From the top of the terrace, a swampy plain destitute of trees, but covered with willows chiefly of the species *Salix arctica* and *S. glauca*, stretches west for nearly four miles, and then a second slope, longer and higher than the first, has to be ascended, at the summit of which the barometer registered a height of twelve hundred feet above the river at the fort. At this

elevation the forest has censed, and the shrubs which occur so abundantly on the first terrace have almost disappeared, and are only represented by an occasional stunted specimen of the arctic willow (*S. arctica*). A small larch (*Larix Americana*) still survives, but barely attains a height of six or eight feet and a diameter of one to two inches.

From the second slope a wide plain reaches westward to the mountains. The walking here is exceedingly difficult, as the surface is covered with the rounded grassy sods which go in the country by the name of *Têtes des femmes*. These project a foot or more above the clayey soil, and are the cause of constant stumbling which becomes somewhat exasperating when one is weighted down with a pack. An attempt to walk on the top of the mounds soon becomes excessively fatiguing on account of the irregular length of the strides, and a slight miscalculation as to distance precipitates the unlucky traveller down into the muddy depths between. When down, the resolve is usually made, and adhered to for awhile, to keep to the lower levels, but the effort required to step over the intervening hillocks presents obvious disadvantages of a different kind.

A walk of five hours, at the rate of about a mile and a-half an hour, brought us to a deep valley occupied by a swift mountain stream, which we forded, and then camped on the opposite bank. This stream, half a mile below camp, joins a small river which falls into Peel River three or four miles above the fort. Its channel is filled with sandstone, and quartzite slabs derived from its banks and from the neighboring mountains.

On the 11th we climbed out of the valley, and following up the main stream, soon reached the "Gap" from which it emerges from the mountains. A halt of a couple of hours was called here for the purpose of allowing the Indians to add to their store of provisions by killing a mountain sheep which one of them observed on a ledge above. The hunt was successful, and the victim proved to be the interesting *Ovis Montani*, var. *Dalli*. This animal resembles the bighorn of the Rocky Mountains to the south in form, but is much smaller, weighing scarcely a hundred pounds, and its hair, instead of being tawny, is almost a pure white. The change in color and size towards the north is evidently a gradual one, as the saddle-backed sheep of the upper Yukon presents characters intermediate between the two extreme varieties.

At the "Gap" the pass through the mountains is eight to ten miles in width, but gradually contracts as we advance, and at our second camp, six miles from the mouth, was reduced to about two miles. The en-

Character of mountains.

closing mountains are regular in outline and somewhat tame in appearance, and rise to elevations above the valley from one thousand to two thousand five hundred feet. The bottom of the valley and the lower slopes of the mountains are clothed with coarse grasses and mosses, above which project naked and often precipitous quartzite cliffs. The stream which occupies the valley at the present time is insignificant in size, and is doing little or no erosive work, and this great cleft through the hard quartzite strata is evidently the product of an earlier age, marked by a much greater precipitation than the present one.

Wide valley.

From our second camp a walk of two miles brought us through the first range and out on a wide longitudinal valley which traverses the mountains in a nearly north and south direction. The stream we had been following up divides here into two branches, and the principal one, reduced now to a large sized brook, bends away to the south. After leaving it the trail leads up a long slope covered with *Tetes des femmes*, and then directly across the valley to an opening in the range ahead. On the farther side of the valley we reached and followed up for a couple of miles a small stream which runs north to Rat River, and directly afterwards crossed the watershed between the Mackenzie and the Yukon and commenced our descent to the latter. The watershed has an elevation measured by the barometer of 2,600 feet above the starting point on Peel River, or about 2,650 above the sea, while the neighboring mountains rise about a thousand feet higher.

Elevation of water-shed.

Two miles west of the watershed the mountains turn suddenly to the north, and the westward-flowing stream which we were following, plunges down a steep decline of fully 1,200 feet. At the base of this declivity it is joined by a large tributary from the south, which swells it to a small river. At the confluence of the two streams is a large flat covered with small groves of the white spruce (*Picea Alba*). The elevation here is over a thousand feet higher than the point at which this tree disappeared on the eastern side of the range.

High tableland.

From the foot of the mountains a high tableland, swelling occasionally into considerable eminences, stretches to the westward. Through this plateau the branch of Bell River, down which the trail leads, has cut a wild and gloomy chasm fully a thousand feet deep. The walls of the cañon are formed of flat-lying sandstones and hard quartzites, and are naked and precipitous above, but fall away in easier slopes below. The bottom of the valley is generally soft and marshy, but hard gravelly terraces, affording good walking, are occasionally crossed. Seven miles from the head of the cañon a large stream comes in from the right, and two miles and a half farther on, a second and more im-

petuous one pours into the main stream from the same direction. After crossing the latter we camped on some firm ground on the farther side.

On the 13th we continued our way down the cañon. Three miles from camp the river washes up against the walls on the right hand side, and the trail, which has hitherto followed the right bank, crosses over to the left. The ford is a difficult one, as the stream is here deep and rapid, and its channel is paved with treacherous quartzite boulders. The greatest caution is necessary in crossing, as a stumble or false step would almost certainly be fatal to one encumbered with a heavy pack.^{Mode of crossing streams.} In fording these swift mountain torrents, it is customary to adopt a communistic plan. The party line up behind a long pole, and keeping a firm hold of it advance into the stream abreast. In this case the person above sustains the full brunt of the current, but is held up by those below, and a stumbler receives the support of those who have kept their footing.

Two miles and a half below the ford the flanking plateau drops suddenly several hundred feet in elevation, and the cañon disappears. A second crossing is necessary here, as the river after escaping from the confining walls of the cañon bends away to the south. At this point the river is wide and shallow, and the crossing was made without difficulty. The stony banks were gay with the yellow flowers of *Senecio lugens*. Four miles farther on the river is again encountered returning from its southern bend, and is crossed for the last time. The river is bordered here by a marshy flat, about two miles in width, through which we waded. Beyond the marsh the trail winds up the steep edge of a high terrace, and then a four mile tramp across a succession of muskegs, brought us to the end of this stage of our journey, and we thankfully threw down our packs on the banks of Bell River.

The Rocky Mountains, along the Peel River portage, present features which differ greatly from those which characterize them farther to the south. They consist here essentially of two ranges, separated by a wide longitudinal valley, and flanked on either side by high plateaus. The eastern range has a width of seven miles, and its higher peaks were estimated to reach an altitude of 2,500 feet above the level of the pass, or about 4,000 feet above the sea. The western range is much narrower, and north of the pass does not exceed four miles in width, but spreads out somewhat more towards the south. The valley of Peel River, which skirts the eastern base of the range is fully 1,200 feet lower than the valley of Rat River on the western side, and the drainage of the mountains is mostly towards the former.

The geological section obtained is somewhat imperfect, as our scanty

Geological
section.

supplies allowed of no delay, but sufficient was learnt to show that the range has on the whole an anticlinal structure, although the general anticline is obscured in places by subordinate folds, and is probably broken by faults. In the eastern plateau the beds are nearly horizontal, but approaching the mountains they incline greatly to the eastwards, and in the centre of the eastern range have dips of from 30° to 70° in the same direction. In the western range the same dip prevails, but the inclination is much less, and the beds flatten out when the mountains are replaced by the elevated western plateau. The horizontal attitude is maintained for some miles, but before reaching the western edge of the plateau the beds bend down and dip gently to the west.

Fossils.

No limestones were observed along this section, and the rocks consist of sandstones, quartzites and shales, all of which are probably referable to the Cretaceous. At the starting point on Peel River the banks are formed of shales, interbedded with some hard sandstones holding carbonized fragments of wood and leaves. In the first fourteen miles the beds are concealed, but shales and sandstones are again exposed on the banks of the valley in which we made our first camp. Some fossils were collected here, among which is a *Discina*, like *D. pileolus*, Whiteaves, a *Macra* and a *Yoldia*, both of which are probably new, but the specimens are too imperfectly preserved to admit of specific determination. Six miles farther west, at the entrance to the "Gap," the trail passes over beds of a bluish, rather compact calcareous sandstone. The beds are coated in places with calc-spar, are highly ferruginous, and weather to a rusty yellow. A *Cardium* and some other poorly preserved fossils were obtained here. In the valley of the river the sandstones are underlain by dark shales. After entering the mountains, only alternating sandstones and quartzites were seen. The beds of this series are greyish in colour, are evenly stratified and are very uniform in appearance all across the range. They have an estimated minimum thickness of 5,000 feet, and may possibly greatly exceed this. The western plateau is built of compact greyish sandstones, passing in places into quartzites, similar to those found in the mountains and evidently belonging to the same formation.

No limestones
or schists in
mountains.

Both Isbister and Petitot mention limestone, schists, and granites, as being found in this section of the mountains, but these rocks were not seen in the section examined by me, nor were pebbles derived from them found in the wash of any of the streams which we crossed. In the valley of the Mackenzie, however, the Devonian limestones immediately underlie the sandstones and shales of the Cretaceous, and it is highly probable that in parts of the range the disturbance has been sufficient to bring these to the surface.

On arriving at Bell River we crossed over to Lapierre House, which is situated on a flat on the western side, but found the post deserted by all but Indians, the officer in charge having left some time before for Fort Macpherson. Lapierre House is simply an outpost of Fort Macpherson, and is kept up principally to facilitate the transit of goods and furs across the mountains, although some trading is also done both with the Loucheux and the Eskimo. It has been in existence about thirty-five years. No farming of any kind is attempted either here or at Fort Macpherson.

The boat which I had sent across the mountains by the McDougal Pass, I was glad to find had reached its destination in good order, and no time was lost in preparing for the descent of Bell River and the Porcupine. My crew down these rivers consisted, besides myself, of one man, an Orkneyman and ex-employé of the Hudson's Bay Company named Skee, whom I met at Fort Macpherson on his way out of the country, and was fortunately able to induce to come with me and go out by way of the Yukon.

The upper part of Bell River has not been explored. At the fort it is a small sluggish stream of forty to fifty yards in width, and a current of less than two miles an hour. The banks are low and alluvial, and the bordering region is covered with willows, birch, aspen and spruce belonging to the same species as those noticed east of the mountains. Below Lapierre House Bell River runs a few degrees east of south for seven or eight miles, and then bending to the south-west flows by Sinclair's Rock with a somewhat accelerated current, and continues on in the same direction to Stony River, a stream nearly equal in size to itself. From Stony River its course is north-west or nearly opposite to its direction in the first reach, for seven or eight miles, and then it bends gradually around to the south-west, and keeps this course until it empties into the Porcupine. Its length from Lapierre House to its mouth is about thirty miles. Besides Stony River, which comes in from the left, it receives a short distance farther down, from the same side, the waters of Eagle River, a stream of about a hundred feet in width. Below its junction with these two streams Bell River becomes considerably enlarged, and in its lower part expands to about a hundred yards in width. No rapids were met with below Lapierre House, and the current seldom exceeds three miles an hour, and is usually much slower.

The valley of Bell River is shallow, and no rock sections occur in the banks below Lapierre House until the cliff at Sinclair's Rock is reached. At this point the river cuts through a range of hills, and coarse arenaceous shales are uncovered, which probably represent an

extension of the same beds that in the mountains are hardened into quartzites. The shales are unevenly bedded, and under the influence of the weather crumble into a talus of sharp, angular fragments. For some miles below Sinclair's Rock the banks are formed of alluvial clays and sands, but shales are again exposed about half a mile below Eagle River. The beds here are softer and darker in colour than those found in Sinclair's Rock, and are better stratified and separate into thinner laminae. They alternate with some beds of sandstone and ironstone. The dip is S. 65° W. $< 20^{\circ}$. Beds of a similar character are exposed again four miles farther down. Here they are horizontal when first seen, but in a short distance bend down and assume a vertical attitude. Below this point dark fissile shales, alternating occasionally with beds of sandstone and ironstone, undulate at all angles in the bank of the river, and are almost continuously exposed until within a few miles of the mouth of the river, when they are overlain and concealed by recent clays and sands.

The rocks exposed along Bell River are unfossiliferous, but are closely related lithologically to the Cretaceous shales and sandstones of the lower Mackenzie and the mountains, and I have little hesitation in referring them to the same horizon.

PORCUPINE RIVER.

BELL RIVER TO DRIFTWOOD RIVER.

Very little information was available in regard to the Porcupine before the present exploration was undertaken. Short accounts derived from hearsay evidence, are given by Richardson and others, but it was not personally visited by any of the numerous travellers who have written of the Mackenzie and the Yukon, although it has been used by the Hudson's Bay Company as a trade route since 1847, and its navigation presents no special difficulty.

The Porcupine heads within thirty miles of the Pelly-Yukon, approximately in latitude $65^{\circ}30' N.$, and after describing a great semi-circular curve to the northeast, falls into the same river a hundred and fifty miles farther down. At its most easterly point it approaches within eighty miles of the Mackenzie, but is separated from it by the main range of the Rocky Mountains. Its total length approximates to five hundred miles.

Exploration of the Porcupine. The upper part of the Porcupine was explored by Mr. Ogilvie in the early part of the present summer. Ogilvie reached the head of the river by a winter traverse from the Pelly-Yukon, and descended it as

Porcupine
River.

far as the mouth of Bell River. An account of this part of the river will be found in his report. The present description treats of the part below Bell River.

From Bell River to Driftwood River, a distance of about thirty miles ^{Character of the Porcupine.} in a straight line, but over forty by the course of the river, the Porcupine has a general north-westerly trend, but makes a couple of minor bends to the north-east. Its width varies from one hundred and fifty to two hundred yards, and its current barely averages two miles an hour. The valley is generally rather wide and shallow, but at one point about ten miles below Bell River, becomes somewhat contracted, and for some miles has the appearance of a wide cañon. The banks here are high and steep, and are formed of broken fragments of hard quartzite. Below the contraction it resumes its usual character. The bordering country is very uneven and swells in places into hills and ridges, most of which appear to have a northerly trend. None of these elevations attain any considerable altitude, and like the lowlands they are clothed with the same monotonous forest of spruce and aspen which has been so often described.

In this reach the river cuts through a very interesting series of Cretaceous section. beds, but the haste with which we were travelling prevented me from examining these in as satisfactory a manner as might be desired. In the first ten miles below the mouth of Bell River, alluvial sands and clays form the banks of the valley, and then hard sandstones and quartzites appear, and are continuously exposed for the next three miles. The sandstones are greyish in colour, very hard, and pass gradually into a compact quartzite. In weathering they break into sharp angular fragments, and the lower slopes of the banks are covered with a steep talus of this material. The dip here is nearly east, and the rocks exposed have a thickness of between three and four thousand feet.

The sandstone series is succeeded and underlain by dark shales in Shale series. interbedded with ironstone. The shales have a light easterly dip, and an approximate thickness of eight hundred feet. They yielded some fossils, among which is a very large belemnite, a finely ribbed ventricose scaphite, which has some resemblance to *Scaphites ventricosus*, and a peculiar ammonitoid shell, which shows a ribbed central portion, while the outer whorl is quite smooth. Mr. Whiteaves states that the fossils are probably Benton, but the specimens are too imperfect to make the correlation certain.

The shales are exposed for about a mile, and are then replaced by shales, hard shaly sandstones and quartzites, interstratified with occasional conglomeritic beds. The sandstones are often somewhat green-

Sandstone,
quartzite and
conglomerate
series.

ish on a fresh fracture, but weather to a yellowish or rusty colour. These beds are brought up by a light easterly dip from beneath the shales, and occur in frequent exposures for a distance of two miles. They have a minimum thickness of two thousand feet. Some of the shaly sandstones of this series are fossiliferous affording numerous specimens of an *Ostrea*, along with a *Pecten*, a *Rhynchonella* and an apparently undescribed species of *Pteria*. These fossils do not afford any definite proof in regard to the age of the formation, but are not at variance with its reference to the Dakota, to which the stratigraphical evidence would assign it.

Continuing down the river, an interval of about a mile occurs in which the beds are concealed, and then sandstones are again exposed, forming the floor of a wide shelving beach on the right hand side of the river. The dip is still easterly, and the descending section has evidently been continuous. The sandstone here is a hard greyish variety, and in its compact texture it approaches a quartzite. It is fossiliferous, and some of the beds are covered with casts of *Aucella mosquensis* var. *concentrica*, the characteristic fossil of the Queen Charlotte Islands formation. This formation occurs in British Columbia, at the base of the Cretaceous, and has been referred by Mr. Whiteaves, on fossil evidence, to a position immediately below the Dakota, a reference which is apparently justified by the facts detailed in the section just described.

Below the point on the river at which the Aucella beds are exposed, the section becomes so confused and is interrupted by so many concealed intervals, that it was found impossible to follow closely the sequence of the terranes.

A mile and a half below the Aucella beds, yellowish-weathering shales and sandstones are exposed, which probably belong to the same series. The easterly dip, which has been maintained for so long, changes here, and the inclination of the beds becomes more variable, and is not infrequently to the west. The sandstones are followed after an interval of three miles by black bituminous looking shales, the relations of which are somewhat obscure, and these by a hard conglomerate, the dip of which is to the south. Five miles farther down ferruginous rusty-weathering shales, striking nearly east and west, and dipping up stream, are again exposed. The beds first seen are very fissile, and are lighter coloured than is usually the case, but are underlain by a black carbonaceous variety resembling the Devonian shales seen along the Grand View on the Mackenzie. Fragments of a brachiopod shell were collected here, but the specimens are too indefinite for determination.

Aucella beds.

Change of dip.

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The shales are underlain by a great thickness of yellowish-coloured coarse conglomerate, occurring in massive beds and lying in an almost horizontal position. The pebbles of this conglomerate, besides the usual quartzose and slate varieties, include boulders of limestone often exceeding a foot in diameter. A high range of hills, which follows the left bank of the valley for some miles, is evidently built of this rock.

The conglomerate is succeeded by soft bluish-looking shales, but the bluish shales junction of the two formations was not observed. The shales after a short interval, are concealed, but reappear four miles farther down, and are replaced shortly afterwards by the conglomerates with which they are associated. The latter evidently constitute the local base of the Cretaceous, as they are underlaid by hard bluish unfossiliferous dolomites dipping at high angles, which have a decided Palaeozoic appearance.

Below the dolomites the section is again interrupted for a short distance, and the next exposures show soft, bluish, lightly undulating shales, similar to those seen farther up. The shales are interstratified with some harder calcareous strata, the surfaces of which are occasionally blackened with carbonized fragments of leaves. The shales form the banks as far as Driftwood River and beyond.

The section obtained in the reach of the Porcupine between the mouth of the Bell River and the Driftwood may be summarized as consisting in descending order of three or four thousand feet of barren quartzites and sandstone, a band of dark shales, probably of Benton age, and a great series of sandstone shales and conglomerates, characterized by holding *Aucella mosquensis* var. *concentrica*, the base of which was not determined. The conglomerates and shales which alternate with one another in the lower part of the reach, may possibly represent in a somewhat modified condition, the two lower divisions just enumerated, but their relations were not definitely ascertained. They form the base of the Cretaceous, as Palaeozoic limestone rises from beneath them in the higher undulations.

DRIFTWOOD RIVER TO THE HEAD OF THE RAMPARTS.

Below Driftwood River the Porcupine makes a sudden bend of several miles to the north, and then turning to the west it follows a general bearing of about 15° south of west to the head of the Ramparts. The distance between these two points, measured in a straight line, is about fifty miles, but measured along the tortuous course of the river, exceeds seventy-five miles. The river in this reach has a width of from two to three hundred yards. No rapids were met with, and the

Character of
the Porcupine
below
Driftwood
River.

current does not average over two miles an hour. Alluvial islands occur at long intervals, and sand and gravel bars are more numerous than in the upper part. The valley varies from one to two hundred feet in depth, and occasionally expands to over three miles in width, and in such cases encloses large wooded flats. The volume of the Porcupine is swelled in this reach by two considerable tributaries, besides a number of smaller streams. Old Crow River enters it from the north about half way down, and Blue-fish River from the south a few miles above the head of the Ramparts. The bordering region is undulating and wooded, and is broken below the Old Crow River by a short range culminating in high bare peaks, the summits of which attain elevations of over two thousand feet above the river. This range has been called the Old Crow mountains, after a Loucheux chief of that name, in whose hunting grounds they are. The outlines of a number of similar ranges, all apparently independent of one another, were observed cutting the horizon at various points.

Geological section.

The geological section becomes much simpler below Driftwood River. Soft bluish shales, with occasional harder calcareous layers, are exposed at the mouth of the river, and again three miles lower down. They are nearly horizontal, but can be seen to undulate slightly in the banks. They are succeeded and underlaid by a band of hard sandstones and quartzites, which are white on a fresh fracture, but weather to a bright conspicuous yellow. A mile farther down the quartzite band folds over a sudden anticlinal, the central part of which consists of a hard, compact bluish limestone, alternating with a more shaly variety of the same rock. The harder limestone beds have a cracked appearance, and are covered with a network of reticulating calcite veins. They are filled in places with broken crinoid stems and other fossils, and are undoubtedly Paleozoic. The contact between the limestones and the overlying Cretaceous rocks has the appearance from the river of being slightly discordant.

Recent disturbance.

The anticlinal swell just referred to, projects above the surface as a hill, and affords evidence in itself of the comparatively recent age of the disturbance which produced it, if denudation be accepted as a measure of time. The curve of the strata is still unbroken by denudation, although the fractured condition of the beds shows that they were bent near the surface and not under any great pressure.

Three miles below the anticlinal the same bluish shales which are exposed above it commence again, and are shown in all the scarped banks until within a short distance of Fishing River. They are horizontal, or are subject to almost inappreciable dips. As we descend the river they become much softer and lose the fissile shaly cleavage

which characterized them where first seen. Interstratified with the shales are occasional harder beds of dark sandstones, which pass in some instances into a conglomeritic condition. The sandstones often show well marked slickensided surfaces, a feature somewhat unusual in soft, apparently undisturbed strata, and the jointage planes are occasionally lined with a thin film of a pinkish mineral, the identity of which has not been made out. Broken coaly particles form a constituent of the shales in some places, but no lignite beds were seen. Limestone concretions, ranging in size up to six feet in diameter, and either arranged in lines or scattered irregularly through the shales, are abundant in some of the sections, and hold fragments of bones and pieces of the test and occasionally entire specimens of a large *Inoceramus*.

The recent deposits overlying the shales consist of alluvial silts, Recent deposits. sands, clays and gravels, and no boulder-clays or other beds referable to the glacial period are seen after leaving the Mackenzie.

Half a mile above Fishing River, the dark Cretaceous shales are overlain unconformably by soft, scarcely stratified, whitish and yellowish clays and sands. No fossils were found in these beds, but they evidently represent some horizon in the Tertiary, and their stratigraphical relations would correlate them with the Bear River Tertiary beds of the Mackenzie, which have been referred by Sir William Dawson, on the evidence of their flora, to the Laramie. Two miles below the first exposure, Tertiary beds are again shown in a scarped bank on the left-hand side of the river. They consist here of yellowish and whitish sands and sandstones, interbedded with a greyish, rather hard conglomerate, made up of quartzite pebbles, fragments of shale, and scales of a silvery micaceous schist, unlike any rocks which I have seen in the country. In the next few miles the coloured Tertiary rocks are exposed at all the bends of the river. Eight miles above the mouth of Old Crow River they are raised up by an anticlinal, and the bluish shales and sandstones of the Cretaceous appear unconformably beneath them. The Cretaceous beds are marked here with numerous impressions of a large *Inoceramus*, some of which exceed three feet in length, but the crumbling character of the rock prevented me from obtaining specimens.

The Cretaceous shales have a very limited exposure here, and are again replaced in the course of a few hundred yards by the Tertiary. Two miles below the Cretaceous outcrop, a small bed of shaly lignite was observed among the Tertiary beds exposed on the banks.

At the mouth of Old Crow River, the dark shales of the Cretaceous again rise to the surface and outcrop along the right bank for a short distance. They are brought up here by the same disturbance to which the Old Crow Mountains, which are directly opposite, owe their existence.

Re-appearance
of Cretaceous.

Old Crow
Mountains.

The Old Crow Mountains were not examined closely, but they appear to belong to the same system of anticlinal uplifts, examples of which are met with so frequently in the valleys of both the Porcupine and the Mackenzie. The lower slopes of the range show dark shales of Cretaceous age, while the higher peaks, judging by the wash in the streams which descend from them, are built principally of hard quartzites similar to those which characterize the Cretaceous farther up the river.

Re-enter
Tertiary basin.

Two miles below the mouth of Old Crow River, the Porcupine bends to the left and enters the Tertiary basin again. At the extremity of the bend the Tertiary beds are well exposed, and consist of whitish and light yellowish sands, clays and gravels. The beds have little coherency, and can be crushed between the fingers. Small nodules and beds of ironstone are developed in some places, but none of these proved to be fossiliferous. In the next twenty miles, or as far as the head of the Ramparts, the sands, clays and gravels of the Tertiary appear with little variety in the scarped banks washed out by the river at the elbows of the various bends. The sections have a general whitish appearance when viewed from a distance, but a closer inspection reveals an alternation of whitish, light yellowish and reddish tints. The rocks of this terrane show little induration, but have sufficient coherency when freshly uncovered to enable them to stand in almost vertical cliffs of from one hundred to two hundred feet in height; but under a long exposure the face of an escarpment crumbles down into a gentle slope, from which the harder beds occasionally project. The following section was measured a short distance above the head of the Ramparts :—

	Feet.
Light coloured, slightly indurated sands.....	10
Greyish sandy clays.....	20
Friable pebble conglomerate.....	8
Reddish clays.....	1
Cream coloured clays.....	5
Light yellowish soft sandy beds.....	15
—	—
	59

The rocks change rapidly in composition when traced along the strike, and beds of sand are replaced by clays or conglomerates in the course of a few hundred feet.

At the head of the Ramparts the Tertiary rocks overlap the Cretaceous and rest directly on hard limestones and quartzites which are probably Palaeozoic.

Before entering the Ramparts the Porcupine makes a sudden bend to the south. Its course is then comparatively straight along a bearing of S. 60° W. for a distance of thirty miles. Beyond this it bends more ^{direction of} to the south, and its direction as far as Rampart House, a further distance of twelve miles, is S. 22° W. Before reaching Rampart House both valley and river run in an easterly direction for about a mile, and then turning again to the southwest the valley becomes somewhat enlarged, and a small flat is interposed between its northern bank and the river, on which the fort is situated.

The Porcupine while passing through the Ramparts contracts considerably, and in places does not exceed seventy-five yards in width. Its current is more rapid than in the upper part, and was ^{character of} estimated to run at the rate of about three or four miles and a half an hour. Short riffles, with a much greater velocity than this occur occasionally, but no rapids or other obstructions were met with, which would prevent the navigation of the stream by small steamers.

The Ramparts is a local name employed by the traders to designate a contracted walled valley or cañon. The portion of the valley of the Porcupine which passes under this name is exceedingly picturesque. In the upper part the banks rise steeply from the water's edge on ^{Picturesque} valley, both sides to heights of from three to five hundred feet, and their green slopes are everywhere broken by shattered pinnacles and bold crags and cliffs of brilliantly tinted dolomites and quartzites standing almost on edge. As we descend the enclosing walls become higher and steeper, and the lighter shades are replaced by more sombre colours. Some miles above Rapid River a band of basalt edged with vertical cliffs, appears above, and gradually descends in the banks of the cañon until it reaches the bottom, and from this on the gorge is ^{Band of basalt.} bounded by even, precipitous walls carved out of this rock. The uniformity of this part of the valley is interrupted at intervals by deep gashes cut by tributary streams through the basaltic covering. Of these the principal one is Rapid River, which enters the Porcupine about seven miles above the post. A mile below Rapid River is the half-way pillar, a projecting column of rock, which was supposed by the traders to be equidistant from Lapierre House and Fort Yukon.

The geology of the Ramparts proved to be too complicated to be unravelled in the few hours which I was able to devote to it, and can only be indicated in a general way.

At the head of the Ramparts the soft unconsolidated Tertiary strata are underlain, as above stated, by a different and much older series. The beds first seen consist of greyish granular dolomites, interstratified with a close textured, very compact variety of the same rock, striking nearly

Rocks in
Ramparts.

north and south, and dipping to the west at an angle of 35° . Farther down the dolomites are associated with limestones, quartzites and a band of dark calcareous shales. The rocks have all been subjected to considerable crushing, due to volcanic action, and in some instances have been so shattered that they crumble completely under the influence of the weather or when struck with the hammer.

Varied
colouration.

The most important rock in the first twenty miles is a peculiar fresh-looking dolomite, the texture of which is so hard and compact that it might readily be mistaken in some cases for a quartzite. It contains, however, very little siliceous matter, and dissolves almost completely in hydrochloric acid. A remarkable feature of this rock is the varied and changing colouration which it exhibits along the valley. The colours range from pure white through light and dark yellow to a bright red, and appear in some places to have an irregular distribution, as if due to subsequent infiltration. The beds are usually tilted at high angles, and the harder strata project above the surface in a more or less ruinous condition, and when brightly coloured, stand out in strong relief against the background of dark green.

Band of shales.

A band of dark calcareous shales, several hundred feet in thickness, is repeated at several points, and was carefully searched for fossils, but without success. The shales are interstratified at some points with bedded traps, and a number of irregular intrusions of the same rock were also noticed cutting the bedding. They pass occasionally into light coloured schists, and often show slaty cleavage.

Quartzites.

Whitish and coloured quartzites, often holding black plumbaginous looking scales, form an important constituent of the section, and granular dolomites and lead-coloured limestones are also well developed, and occasionally form high cliffs.

Decayed rocks.

A noticeable feature of the section is the peculiar alternation of strata softened and decayed for many feet below the surface, with unweathered varieties of apparently the same, or only slightly different rocks. I was at first inclined to believe that some of the soft Tertiary beds which overlie the dolomites and associated rocks at the head of the Ramparts had been folded up with the latter, but was led on farther examination to abandon this view.

The succession of the different terranes was not ascertained, as the section is very much confused, and is broken through repeatedly by trap dykes, and would require considerable time for its elucidation.

Ten miles above Rapid River the Porcupine has cut through a thick sheet of basalt. The basalt is first seen crowning in long cliffs the banks of the valley, but is brought down by a light westerly inclination to the surface of the water, in a distance of six miles. Beyond

this it undulates at low angles along the valley, and occasionally rises sufficiently to expose the underlying shales, quartzites, dolomites and limestones.

The basalt shows no evident columnar structure. A well marked horizontal divisional plane was traced for some distance, and may possibly indicate the junction of two flows, as slight differences in coloration were noted above and below it. In texture the basalt ranges from fine grained to a moderately granular condition, but also becomes vesicular in places, and passes into an amygdaloid. It is composed principally of augite and olivine, with some magnetite and titaniferous iron, and is almost destitute, at least in the hand specimens collected, of plagioclase.

At Rapid River, and for some distance above and below, the basalt sheet rises in the banks, and the underlying rocks, consisting here of ^{under} dark shales, old looking cleaved slates, quartzites and dolomites, all dipping at considerable angles, are brought into view. Two miles below Rapid River the basalt dips below the surface, and the older rocks are not seen until near Rampart House.

RAMPART HOUSE TO THE MOUTH OF THE PORCUPINE.

We reached Rampart House on the 20th July, the descent of the river from Lapierre House having occupied four days. We travelled mostly at night, in order to avoid a strong head wind which blew up the river every day. It is customary, however, in these latitudes to work in the night rather than in the day, during the period of six weeks or so in which the sun remains above the horizon. The light is sufficient, while the temperature is somewhat lower, and the mosquitoes are less troublesome.

Rampart House is the most distant of the Hudson Bay Company's posts, and was established to replace Fort Yukon, after the site of the latter had been determined to be in Alaskan territory. This post was originally situated twelve miles farther down the river, but the position of the buildings in regard to the boundary being doubtful, these were burnt by the Hudson's Bay Company, and new buildings were erected on the present site. As a fur post it barely pays expenses, owing to the heavy cost incurred in the transportation of furs and goods, and is kept up mainly as a protection against the encroachments of traders from the west.

The Indian hunters trading at Rampart House number about eighty. They belong to the Loucheux branch of the Tinneh family, but speak a slightly different dialect from that used by the Mackenzie River Lou-

Indians at
Rampart
House.

Arrangements
for trip.

Rocks below
basalt.

Wide gravel
flat.

Tertiary rocks.

Width of
Tertiary basin.

cheux. They are Christianized, and missionaries sent out by the Church Missionary Society have been working among them for some years. A small church has been built in the vicinity of the post.

I remained a few hours at Rampart House for the purpose of taking an observation for latitude, and making arrangements for the trip to Fort Yukon. An Indian was engaged to accompany us, and I was fortunately able to obtain a supply of dried meat from Mr. Firth, the officer in charge of the post. A report had reached the fort that a steamer belonging to the Alaska Fur Company would pass Fort Yukon on its way to Forty Mile Creek, in a few days, and I decided, as we would now traverse Alaskan Territory, and had no object for delay, to hurry down to the forks as fast as possible and endeavour to secure a passage on the steamer up the Yukon as far as the Canadian boundary. We descended the river, battling against a strong head wind the whole way, in three days, but learned on our arrival, much to our disappointment, that the boat had already passed.

The distance from Rampart House to the mouth of the Porcupine, measured in a straight line, is about one hundred miles, but is fully one hundred and fifty by the course of the river. The general direction is about S. 60° W. The current is uniform, with few riffles and no rapids, and has an average rate of about three miles an hour.

The Ramparts continue for two miles below the fort, and present the same features which characterize them above. Opposite the fort, the basalt sheet rises again, and alternating bands of shales, slates, limestones, dolomites and quartzites, with in one place a white cliff of coarsely crystalline calespar, are seen beneath. Eight miles farther down, it sinks beneath the surface, and massive walls of basalt and amygdaloid then border the river as far as Howling-Dog-Rock, at the foot of the Ramparts.

Below Howling-Dog-Rock, the river intersects for some miles a wide gravel flat, the former site of the fort, and then bends away to the north. An exposure here of clays, greyish and yellowish sands and soft pebbly conglomerate, shows that the river has entered a second Tertiary basin. The rocks are all very soft, and are similar in appearance to those occurring above the Ramparts. No fossils were obtained from them. Sections of unconsolidated Tertiary strata are exposed again at the extremity of the bend, and at several points in the next five miles, and are then replaced by shales and slates of an older series. They are overlain by recent silts, sands and gravels.

The width of the Tertiary basin along the river does not exceed seven miles, but it is highly improbable that this represents its full

size, and the appearance of the flat country to the north would seem to show that it extends for a considerable distance in that direction.

The shales and slates which succeed the Tertiary are overlain in the course of a mile by basalt. The basalt is exposed for a short distance on the left hand bank, and probably represents a projecting spur from the main sheet. It was not seen again. Two miles below the basalt exposure the shales and slates are associated with rusty coloured limestones, and at the mouth of Succor River, three miles farther down, the same rocks are again seen. In the next fifteen miles yellowish-weathering limestones, rising occasionally into abrupt cliffs, are exposed in a number of places. This part of the valley goes by the name of the Lower Ramparts, but the rocky walls are low and disconnected, and are seldom developed on both sides of the valley so as to form a canyon. The limestones yielded *Atrypa reticularis*, together with some fragmentary specimens of corals, and are probably referable in part at least to the Devonian. At the lower end of the Lower Ramparts, the limestones are interbedded with dark shales similar to those associated with them above Succor River. The shales are unfossiliferous, but from their position are probably Cretaceous. They are exposed at intervals for two miles, and are then overlain unconformably by the yellowish and light reddish clays and sands of the Tertiary, and the latter in turn sinks in a short distance, beneath alluvial sands, clays and gravels.

From this point on to the mouth of the river, a distance in a direct line of sixty miles, no further exposures of the older rocks are seen. The valley disappears, and the river serpentine through a wide plain, elevated only a few feet above its surface. At the elbows of the numerous bends the cut banks show small sections of clays and false-bedded sands and gravels, either alluvial or lacustral in their origin. The bordering plains extend to the horizon on either side, unbroken by a single elevation, and their extent and uniformity taken in connection with the character of the beds seen along the valley afford strong grounds for the assumption that a lake basin or abnormal expansion of the river once existed here and has since been silted up.

The principal streams which the Porcupine receives in this part of its course are the Salmon from the right, and Black River and Little Black River from the left. For some miles above its mouth it divides around numerous islands, and branching channels become so frequent that care has to be exercised to select the right one. Before reaching the Yukon we left the main stream, and turning to the left entered a small channel which is reported to flow in opposite directions, depend-

Exposure of
basalt.

Lower
Ramparts.

Age of
limestones.

Wide plain.

Tributaries of
Porcupine.

ing on the relative heights of the water in the two rivers. Our hopes that the current would set in our favour were doomed to disappointment, as we no sooner rounded the bend than we passed from the brown water of the Pine into the milky flood of the Yukon, and found ourselves struggling against an impetuous current of five or six miles an hour. Fort Yukon is situated a mile and a half above the confluence of the two streams, and it required nearly two hours of hard work to ascend that distance.

OLD FORT YUKON TO FORTY MILE CREEK.

At Fort Yukon I had the pleasure of meeting the Rev. Mr. Canahan, of the Church Missionary Society, who was on his way to Meklukahyèt to take charge of a mission. Mr. Canahan's news was far from cheering, as he informed us that the steamer which we expected to meet had passed up the day before.

Routes to the coast.

Two courses were now open to us in order to reach the coast and outside communication; either to descend the river to St. Michaels and sail from that point to Victoria or San Francisco, or to face the nine hundred miles or so of rapid current and difficult navigation above, and ascend it to the head of the Lewes, and then cross the Coast Range by the Chilkoot Pass. The former is by far the easier route, as the lower Yukon possesses a strong steady current, and is free from dangerous rapids, and the temptation to adopt it was almost irresistible, but as it lay altogether outside of Canadian territory I decided, if possible, to try and ascend the stream. To do this, however, promised to be a matter of no ordinary difficulty. The short, square-sterned boat which I had hitherto used, was built to carry a load down stream and was altogether unsuitable to make an up-stream journey in, and an attempt to force it for hundreds of miles against a five or six mile an hour current seemed well nigh hopeless, but no other was available. Our provisions were also running short, but Mr. Canahan kindly supplied our deficiencies in this respect to some extent, and we expected to be able to obtain fish from the Indians along the river. Trader John, the Indian who piloted us down from Rampart House, and had proved himself a capable and willing fellow, was induced, after some persuasion, to accompany us as far as Forty Mile Creek, and on the 25th of July, after a delay of four days, we succeeded in making a start.

Early exploration.

A sketch of early exploration on the Yukon has been given by Dr. G. M. Dawson, in Part B, Annual Report of the Geological Survey for 1887-88, and it will be unnecessary to repeat it here. Fort Yukon, which was originally one of the best built forts in the north, is now a

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thing of the past, and with the exception of one of the outbuildings, which has probably also disappeared by this time, has been torn down to supply wood for the steamers plying on the river.

While in possession of the Hudson's Bay Company some gardening was done in the vicinity of the fort, notwithstanding the fact that it is situated almost on the Arctic circle. Potatoes and other vegetables were raised, and barley is reported to have ripened. On the MacKenzie River, gardening ceases to the north at almost the same latitude.

Above Fort Yukon the river cuts through the same low wooded plain which has been described as bordering the Porcupine above its mouth, and like the latter, only on a much greater scale, its waters flow by numberless interbranching channels through a labyrinth of islands. Its width in this reach is reported to range from three to ten miles or more, but as we kept the left bank the whole way up, and the opposite shore was always concealed by islands, I was unable to verify this statement. The river however has here, practically, no confining valley, and the soft sands and clays which underlie the adjoining plain offer little obstruction to an indefinite expansion. New channels are opened up with each succeeding flood, and older ones blocked by the deposition of sediment. Notwithstanding the great width, the velocity of the current is undiminished, and the upstream navigation of this part, especially in high water, is attended with greater difficulty than any other portion of the river. Beaches are seldom present, and tracking is impossible except for trifling distances at long intervals. The water along the cut banks is too deep a few feet from the shore for poling, and to advance we were obliged to combine the use of an oar on the outside, a pole on the inside, while I steered and paddled behind. Even this complicated method of propulsion often became impracticable, and progression in some places was only attainable by clinging to the overhanging branches and pulling ourselves up foot by foot. For long reaches the banks are undermined by the wash of the stream, and as the boat creeps along beneath the overhanging wall from which masses of sand and other material are momentarily falling, it is constantly threatened with destruction. Vexatious delays are also caused by the numerous trees which have been undermined and have fallen forwards into the stream, but still cling to the bank by their roots. Above these, driftwood accumulates until it forms a projecting point around which the current swirls with redoubled velocity; and to pass them is often the work of hours. The width of the river is so great that difficult spots cannot be avoided as in other streams by crossing to the opposite bank, and the ascent must be made entirely on one side. The eastern side is usually preferred.

Gardening at
Fort Yukon. 1

Numerous
channels.

Difficult
navigation.

Length of
island-filled
stretch.

The length of this expanded island-filled stretch above the mouth of the Porcupine was estimated at seventy miles, although a miner, the only one so far as I could hear, who had ascended it, assured me that it could not be less than three hundred and fifty miles. His estimate must, however, be taken rather as a measure of the difficulties he encountered than of the true length. We made the ascent in five days, but to do this were obliged to work at our full capacity for fourteen or fifteen hours a day. With a proper boat much better time could have been made.

Older rocks
hidden.

The older rocks along this stretch are deeply buried beneath a thick accumulation of recent sands, clays and gravels, and no exposures were anywhere seen.

Chief Senatee.

Before reaching the head of the islands we crossed to the right bank, and on our sixth day passed the camp of Senatee, the head of the Fort Yukon Indians, and the most powerful chief in the whole Yukon country. Many stories are told of cruel murders and rapes committed by Senatee in days gone by, but time has now tamed his ferocious disposition, and changing circumstances have shorn him of much of his once absolute authority. He received us hospitably, and after an exchange of fish for tobacco had been made, commenced a long oration, descriptive of his enduring love for the English (Hudson's Bay Company) and his regret that they had left the country, and his general dislike of the Yankees (Alaska Fur Company), but as time was precious the harangue was cut short by the present of a couple of handfuls of tea, the probable object for which it was made, and we proceeded on our journey.

River
contracts.

Above the Indian camp the river commences to contract. It bends more to the east, and is bordered by narrow beaches, a welcome change, which enabled us, much to our relief, to substitute the tracking line for the poles and oars, and to make better progress with less exertion. The shore here is strewn with blocks of dark carbonaceous looking cleavable shales, and on the eastern side of the river bedded rocks, probably of the same description, could be seen *in situ*, but were not examined, as a crossing meant the loss of several miles wearisomely won, and was only made when rendered necessary by the exigencies of the navigation.

Increased
elevation of
bordering
region.

The elevation of the country bordering the river is here higher, and a considerable valley is developed. Fifteen miles above the Indian camp the river is reduced to about half a mile in width, and assumes an easterly direction. A crossing to the eastern side was effected here, and a line of cliffs which made their appearance seven miles below, was found to consist of massive eruptive rocks, which

are described in my notes as basalts and fine and coarse grained dolomites, but unfortunately the specimens have mis-carried. The volcanic rocks here are, as a rule, coarser textured and older looking than those seen at the Ramparts on the Porcupine, and no amygdaloids or vesicular varieties such as occur there were noticed. It is uncertain whether they form parts of the same flow or not, although the relative position of the two areas and the northerly trend of the elevated country leads to the supposition that they do, and in this case the westerly edge of the flow would correspond in a general manner with the eastern boundary of the great plain which extends up the Pelly-Yukon and Porcupine from their confluence.

The basalt and associated igneous rocks enclose numerous detached masses of shales derived from the underlying terranes, and dark shales and limestones tilted at high angles project up into them in many places in a similar manner to that noticed on the Porcupine. They were traced along the river for fifteen or twenty miles, and are then replaced by a confused succession of shales and limestones, probably referable to a large extent to the Carboniferous, alternating with the dark shales, sandstones and quartzites of the Cretaceous. The whole series is greatly disturbed, and folded closely together, and the beds often show vertical dips. The general strike is S. S. E. The shales and associated limestones and sandstones are exposed in continuous sections for seven or eight miles, and are then again almost buried beneath a second basaltic occurrence, and only the higher points of the old rugose surface rise into view above the bottom of the valley.

The line of contact of the Tertiary basalts with the underlying sediments in this region, both on the Yukon and the Porcupine is, speaking generally, nearly coincident with the present level of the rivers.

The second basaltic area where cut by the river has a width of ten or twelve miles. Above it the rocks are concealed on the eastern side for some distance, and then the shales and sandstones of the Cretaceous outcrop on the banks, and are present all the way to the Tatondue, a distance of about thirty-five miles. The beds are sometimes horizontal, but usually undulate at varying angles, but seldom to such an extent as to expose the underlying Paleozoic limestones. Conglomerates consisting largely of small pebbles of schist, quartzite and slate, imbedded in a hard sandstone matrix, are occasionally associated with the shales and sandstones, and in one place about eight miles above Charlie's village, attain a great development. They overlie the shales at this point. Some miles below the mouth of the Tatondue speci-

mens of the characteristic Queen Charlotte Islands' formation fossil *Aucella Mosquensis* var. *concentrica*, were collected from the beds below the conglomerates.

Depth of valley.

The valley of the Pelly-Yukon becomes gradually deeper as we ascend, and above Charlie's village the banks were estimated to have an elevation in places of from eight hundred to a thousand feet.

Foldings.

Above the mouth of the Tatondue the foldings increase in severity, and the Palæozoic limestones and shales are brought up and alternate in broad bands with the shales, sandstones and conglomerates of the Cretaceous. A black carbonaceous variety of shale is repeated at a number of points, and often shows polished slickensided surfaces, due to the crushing to which it has been subjected, which simulate very closely the appearance of anthracite. The alternation of the Cretaceous beds with the older limestones and shales continues until near the boundary, a distance measured along the river of about forty miles. No fossils were found in this part of the river, but lack of time prevented a careful search for them.*

Schistose rocks ^{replace shales,} _{limestones, etc.} A short distance below the boundary the rocks referred to above are replaced by a very different looking set, consisting mainly of altered volcanic rocks, and characterized by a general greenish colour. Among them are important bands of serpentine, hard quartzose, sheared and altered greenish schists, softer greenish chloritic looking schists, silvery mica-schists, diabases, shales and slates. Picrolite was noticed in several places, and beds of chert are not uncommon. The schistose beds must underlie the limestone series, (Carboniferous?) although the dip would place them above, as the latter is overlain directly in many

* Mr. Ogilvie has furnished me with the following geological notes obtained on his traverse from the mouth of the Tatondue across to the head water of the Porcupine and down the latter stream to its confluence with Bell River:—Dark shales overlain by fine grained conglomerates which are doubtless the equivalents of the Cretaceous beds observed on the Pelly-Yukon, occur along the Tatondue for twenty-seven miles from its mouth. At two points in this distance limestone rise to the surface from beneath the shales and by their superior hardness contract the valley into short cañons. The conglomerates are described by Ogilvie as weathering in some of the ridges and mountains into picturesque castellated cliffs. In the upper part of the valley of the Tatondue the Cretaceous shales and conglomerates are replaced by greyish Palæozoic limestones. Similar limestones were also met with all across the watershed separating the Tatondue from the Porcupine where they form a range of high mountains and down the latter stream as far as the Cathedral Rocks. At two points on the Porcupine, viz.: two miles and ten miles respectively below the forks, the limestones are underlain by reddish mottled sandstones similar in appearance to those occurring at Sault Ste. Marie. Below the Cathedral Rocks dark shales of Cretaceous age appear again, and were the only rocks observed all the way to the mouth of Bell River, where connection was made with my traverse down the Porcupine.

An interesting fact noted by Ogilvie is the emission, near Sheep Mountains, of sulphuretted hydrogen gas in large quantities from the surface, and he states that he was informed by his guide that a small lake a short distance from the trail is kept constantly agitated by the escape of similar gas, and that the sulphureous fumes prove fatal to all animals which venture near. East of the Rocky Mountains sulphuretted hydrogen gas issues in numerous places from the petrolierous limestones of the Devonian, but it is possible that its presence here is due to volcanic action.

places farther down the river by the shales, sandstones and conglomerates of the Cretaceous.

East of the river above the boundary, and running parallel with it ^{Limestone} range, for some distance, is a high naked range, built of limestones striking in a south-easterly direction and dipping at high angles towards the river. Resting on these, and apparently overlying them, are the rocks just described.

The schistose beds alternate occasionally with limestone bands, altered in places into marble, and are traversed in all directions by quartz veins. They are exposed all the way to Forty Mile Creek and beyond. They are of the greatest economic importance, as they constitute the gold bearing rocks of the district, and are on the strike of ^{Economic} ^{importance of} schist belt. the same metalliferous zone on which Cassiar and the other principal mining camps to the south are situated, and which has now been traced northwards across Canadian territory from the 49th parallel to the eastern boundary of Alaska, a distance of fully twelve hundred miles.

Four miles below the mouth of Forty Mile Creek, a small stream was passed coming in from the opposite side, on which a coal seam is ^{Coal seam.} reported to occur, but nothing definite was learned about it.

FORTY MILE CREEK.

We arrived at Forty Mile Creek on the 9th August, fourteen days ^{Arrive at Forty} _{Mile Creek.} having been occupied on the journey up from Fort Yukon. This is the headquarters of the miners on the Yukon, and thirty or forty men were camped here waiting for reports from the various prospecting parties which were exploring the surrounding country, and ready to start at a moment's notice. The present season proved very unfavourable ^{Unfavourable} _{season.} for mining operations on account of the persistent high water, and with the exception of a short period early in the summer, very little work was done on Forty Mile Creek, and the amount of gold taken out was ^{Wield of gold.} estimated at scarcely \$15,000. A few days before my arrival a stampede had been made for Beaver River, a northern tributary of the Yukon, which is stated to enter the latter about a hundred and twenty miles below the mouth of the Porcupine, but with somewhat disastrous results. The amount of information required to stampede a mining ^{Stampede of} _{miners.} camp is very small, and in the present case was almost ridiculous. A report was brought up by the men on the steamer that a miner had boarded the boat at the mouth of Beaver River, and after talking in a hurried manner to the captain, had suddenly departed, and in his haste had left his purse behind him. The miners reasoned that

nothing but a rich find would cause such an excitement, and a hundred and fifty men immediately loaded their boats and started on a wild goose chase down the river, only to meet with disappointment at the end of their journey. A few received a passage up again on the steamer, but the greater number drifted on down towards St. Michaels, and left the mining country altogether.

Difficulties in prospecting.

Prospecting in the Yukon country is attended with peculiar disadvantages, and requires men of more than ordinary perseverance and endurance for its successful prosecution. The Yukon itself is very swift and difficult to navigate, but is easy as compared with many of the tributary streams which are simply a long succession of cañons, whirlpools and rapids, and skill and courage in a high degree, in addition to a golden bait, are necessary in order to brave the perils of their ascent. Provisions are high priced and scarce, and in the upper part of the river cannot be obtained at all, and supplies for the summer must be packed across the Coast Range in the early spring and sledged for two hundred miles down the river to the lower end of Lake Labarge before the break up of the ice, in order to be on hand when the season opens. Added to this is the shortness of the period available for work, which under the most favourable circumstances never exceeds three months, and in seasons of exceptional high water, such as the present, is very much less. In view of these drawbacks prospecting must proceed slowly, and up to the present has been confined almost entirely to the larger and more accessible streams.

Yield of gold.

The most important strike made so far has been on Forty Mile Creek, on which coarse gold was discovered in 1886. This discovery occasioned a rush towards the creek of nearly all the miners in the district. In 1887 over 200 men were actively and successfully employed along the numerous bars, and the total yield for the season was variously estimated from \$65,000 up to \$150,000. The present season has proved much less remunerative, partly owing to the unfavourable state of the water and partly to the fact that the rich claims first discovered have been worked out, the auriferous gravels being of little depth and easily exhausted. The most productive part of this stream is west of the Alaska boundary. It has a total length, according to the miners, of about 150 miles, of which only the lower twenty miles are in Canadian territory, and in this part very little work is now being done. The average value of labor is \$10 a day, and bars which yield less than this are soon abandoned.

No important strike was made anywhere in the district in 1888.

Argentiferous galena.

A lode of argentiferous galena crosses Forty Mile Creek a short distance above its mouth, and a specimen brought back by Mr. Ogilvie

was assayed in this office by Mr. Hoffmann, and found to contain $38\frac{64}{100}$ oz. of silver to the ton. Tellurium is reported from the head of the stream, and seams of coarse serpentine asbestos occur near its mouth.

Some days were spent at Forty Mile Creek in making preparations for the long trip up the river and, in building a long, narrow, sharp-ended boat, modelled after the pattern of those used by miners in ascending swift streams. Trader John, who had helped us gallantly in the ascent from Fort Yukon, turned home from here, and a miner named Buckley, was engaged for the remainder of the trip. Prepare for trip up river.

FORTY MILE CREEK TO THE MOUTH OF THE STEWART.

We left Forty Mile Creek shortly after noon on the 14th August, and Leave Forty Mile Creek. passed the mouth of the Stewart early on the morning of the 19th. The distance measured along the river is about 120 miles. The direction as far as Fort Reliance is nearly east, but beyond that point the river bends slowly round and runs almost west for a few miles, after which it maintains a general southerly course to the mouth of Character of river. the Stewart. The width of the river in the lower portion seldom exceeds half a mile, but above Fort Reliance it gradually enlarges, and in the southerly reach occasionally exceeds a mile in width. In the expanded stretch, however, much of the surface is occupied by islands. The current is swift and uniform, and at a medium state of the water runs at the rate of five miles an hour. Beaches line the shore, and tracking, except at very high water, is possible nearly the whole way.

The valley of the Yukon between Forty Mile Creek and the Stewart, Character of valley. and on to the mouth of the Pelly, is cut through an elevated undulating plateau, on which rest numerous low ranges of rounded and partially bare hills, but is not crossed by any well defined mountain range. It is somewhat uniform in appearance, but affords many picturesque and even grand views. Bluffs of rock of a more or less precipitous nature, are of constant occurrence, and bold rampart-like ranges of interrupted cliffs, separated and continued upwards by steep grassy or wooded slopes, characterize the banks for long reaches. The flats are few and unimportant, and as a rule the river washes the base of the banks on both sides. The width of the valley varies from one to three miles, and its depth from five to fifteen hundred feet. Its great size, taken in connection with the hard character of the crystalline rocks through which it has been excavated, afford evidence of Age of valley. great age, and point to an origin long antecedent to the glacial period.

The same fact is also emphasized by the remarkably uniform grade which the river has worn across terranes of heterogeneous hardness, ranging through the whole geological scale in its long course from Rink Rapid to the sea, a distance of nearly 1,700 miles.

Rocks observed.

Rock sections are numerous along the valley, but the geology is intricate and difficult, and somewhat confusing to a traveller passing hurriedly through along one line. Above Forty Mile Creek the same series of micaceous and altered greenish schists and slates which obtain below are continued for six or eight miles, and are then replaced by greyish granite. The schists are traversed by both quartz and calcite veins, usually of small size. They dip at high angles, and have a general south-south-easterly strike. The granite is a medium-grained, somewhat altered variety, showing no distinct foliation. It is composed principally of quartz, plagioclase, orthoclase, muscovite, biotite and epidote. From the central granitic mass a set of dykes radiate out into the surrounding schists. The dykes often pass in between the beds, but were also seen cutting across them. Above the granite boss the schistose series resumes again and continues as far as the bend above Fort Reliance. These rocks are broken up in several places by granite intrusions, and the granite appeared to be itself cut in one place by a darker and more basic igneous rock of which I did not obtain specimens. A specimen of rather coarse textured granite, collected above Fort Reliance, holds numerous grains of copper pyrite, and may possibly be auriferous, but has not been analyzed. The schists occasionally show copper stains running parallel with the foliation.

Dykes.

Some miles above Fort Reliance a band of dark argillites, interbedded with limestones, crosses the river. Like the schists it is traversed by numerous quartz veins. It is followed for several miles by schists of various kinds, but usually more or less micaceous, and occasionally passing into a well foliated rather fine grained mica-gneiss. The latter increases in relative proportion, and assumes a coarser texture as we ascend the river. Igneous granitic intrusions occur every few miles.

Granite intrusions.

Fifteen miles below Sixty Mile Creek, a peculiar looking soft greenish rock consisting of glossy talc, and green serpentine was found at several horizons interbedded with the schists. The square columnar crystals from which the serpentine has been derived still preserve their original form, and penetrate in all directions the lighter coloured talcose matrix. They show under the microscope traces of the quadrangular cleavage of augite, but are otherwise completely altered.

Exposures opposite Sixty Mile Creek.

Opposite Sixty Mile Creek the exposures show lustrous muscovite-mica-schists, dark biotite-mica-schists grading into mica-gneisses,

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hornblende gneissic schists and compact felsitic rocks indistinctly foliated. With these are associated greyish biotite granites, and a coloured granitoid or syenitic rock, consisting of orthoclase, plagioclase, quartz, clorite and epidote. The proportion of quartz in this rock is small and the crystals are greatly crushed and broken. A second variety of this rock shows large, coloured crystals of felspar, porphyritically distributed through a fine-grained micro-crystalline base.

From the vicinity of Sixty Mile Creek to the mouth of the Stewart, Rocks between Sixty Mile Creek and the Stewart. the rocks are older looking and more distinctly gneissic than those observed farther down the river. The most abundant variety is a light reddish-coloured, medium-grained, well foliated mica-gneiss, composed of quartz, orthoclase, plagioclase, biotite and muscovite. Epidote, clorite, calcite and ilmenite are also nearly always present. In some cases the micas are replaced altogether by chlorite. With the gneisses are associated several varieties of mica-schists, and occasionally some hornblende schists. Numerous veins of coarse pegmatite, quartz, and less frequently calcite, cut the beds in all directions, and are present in nearly every section.

STEWART RIVER TO THE PELLY.

The Stewart River has not been explored. At the mouth it is two hundred yards wide, but the current is not rapid, and it apparently carries less water than either the Pelly or the Porcupine. It is reported to be navigable for two hundred miles above its mouth. Gold was discovered on it in 1885, and in that and the following year, gold to the value of \$100,000 was obtained from it, according to an estimate made by Dr. Dawson on information from miners. The principal bars were, however, exhausted in these two years, and in 1887 the yield diminished to about \$5,000, but this was partly due to the withdrawal of most of the miners to Forty Mile Creek. In the present year an attempt was made by two prospectors to trace the gold to its source but without success. "Colours" were present as far as they ascended, but not in paying quantities, and no tributaries were found down which the gold in the lower part of the river might have descended. They report that the river grows in its upper part by the reception of numerous small streams heading in swamps, none of which are gold-bearing. An important feature of the river is the constant recurrence along it of high gravel terraces, most of which are more or less auriferous, and occasionally yield as high as a cent a pan, and could probably be worked profitably on a large scale. It is possible that the gold found on the bars in the river is concentrated from these. High gravel terraces.

From the mouth of the Stewart the Pelly-Yukon trends in a south-

westerly direction for ten miles to its junction with White River. In this reach it averages a mile in width, and is filled with islands. The banks of the valley are steep and rocky, and were estimated at from 800 to 1000 feet in height. Garnetiferous m^{ist} was noticed a short distance above the Stewart, and dark ha^m -schists and light reddish well foliated gneisses are exposed all along. An extensive system of quartz veins is developed along here, and gold-bearing quartz is reported to have been found.

White River.

White River, like the Stewart, has not been explored, and has only been ascended by miners for a distance of sixty miles from its mouth. A view up it from the opposite bank of the Pelly-Yukon showed a wide valley filled with countless bars and islands between which the divided stream threaded its tortuous course. Its current is swift, and it precipitates itself into the Yukon with a force sufficient to drive its muddy water half way across, but scarcely to force it up on the opposite bank in the manner described by Schwatka, and the two streams flow side by side for several miles before their waters become completely fused. The turbid character of the White River is famous, and sufficient sediment is brought down to change the color of the whole Pelly-Yukon flood from a pale green to a milky white. White River is reported to head in glaciers descending from high mountains, but nothing very definite is known concerning it. "Colours" of gold have been obtained from it, but no paying bars have so far been discovered.

**White River to
the Pelly.**

From White River to the Pelly the distance is ninety miles. The direction is at first south-westerly, but the river soon bends round to the east and follows an E. S. E. bearing the greater part of the way. The width of the river is somewhat reduced, and varies from a quarter to half a mile, while the current averages about five miles an hour. Islands occur at intervals, but are less numerous than in the reaches below. The valley preserves its usual depth of from 800 to 1,000 feet, but for some distance above White River the banks are more wooded and show rocky bluffs above supported on steep slopes below. Farther up it is again bordered by steep gneissic and basaltic cliffs. Gravel terraces occur occasionally and appeared to increase in height as we ascended.

**Character of
rocks.**

The prevalent rock for many miles above White River is a hard, granular and often moderately coarse-grained, Archean looking mica-gneiss of somewhat varied mineralogical composition. This occasionally passes into mica-, chlorite- and hornblende-schists. The minerals most commonly present are quartz, plagioclase, orthoclase, biotite, muscovite, chlorite, hornblende, epidote, calcite, magnetite and ilmenite. In some cases the rock is greatly crushed and altered, and

the micas and hornblendes are replaced almost entirely by chlorite. Plagioclase is always present and often in greater abundance than orthoclase. Quartz veins occur less frequently as we ascend, and are replaced by veins of coarse pegmatite. Igneous rocks are almost absent in the lower part of this reach, but coarse granites and diorites were met with about twenty-five miles below the mouth of the Pelly. Three miles above this point the older rocks are covered ^{Tertiary lavas.} with vesicular lavas of Tertiary age. The lavas are exposed for a short distance and then recede from the river at a bend which the latter makes around a high terrace built of coarse gravels. Resting on this terrace is a small bed of white volcanic ash, frequent occurrences of which were noticed on the Pelly by Dr. Dawson, and are described in Part B., Annual Report, 1887-88. Above the gravel terrace the lavas resume, and are present all the way to the Pelly. They are underlain by gneisses similar to those described before, and by granites and diorites. A specimen of diabase-porphry composed of crystals of augite and plagioclase porphyritically distributed through a micro-crystalline chloritic base, was obtained from the cliffs west of the flat on which Fort Selkirk was situated.

After reaching the site of Old Fort Selkirk, at the confluence of the Pelly and Lewe rivers, my journey was continued up the last-named stream and over the Chilkoot Pass to the sea, which was reached on the 15th September, 1888. This part of my route, therefore, coincides with that followed and examined in 1887 by Dr. Dawson, and is described by him in Part B., Annual Report of the Geological Survey, 1887-88.

APPENDIX.
METEOROLOGICAL OBSERVATIONS.

The barometer readings are those of a pocket aneroid.

The temperature is stated in degrees Fahrenheit.

The force of the wind, when given, is estimated according to Beaufort's scale.

The character of the clouds is denoted by the usual letters or combination of letters (Howard's classification).

LOCALITY.	DATE.	HOUR.	BAR.	THERM.	WIND.	CLOUDS.	WEATHER AT TIME.	REMARKS.	
								AIR.	MIN.
1887.									
Forks of the Liard and Dease, 30 ft.	June 25	8 p.m.	27.79	.....	Variable,	S.	Cloudy.	"	
above river	" 25	8 a.m.	27.81	.....	S. W.	K.S.	"		
Liard River, mouth of Highland River	" 25	7 p.m.	27.42	.....	W.	K.S.	Overcast.		
" 27	6 a.m.	27.42	.....	17	W.	K.S.	"		
" 27	7 p.m.	27.55	68	40	W.	K.S.	Cloudy.		
Little Cañon, Liard River	" 28	28.03	47	40	Variables.	K.S.	"		
Porcupine Bar	" 28	6 a.m.	28.06	50	S.W.	K.S.	"		
" 29	6 a.m.	28.06	50	50	.....	K.S.	"		
Cranberry Portage	" 29	7 p.m.	28.05	60	S.W.	K.S.	"		
" 30	6 a.m.	28.04	46	37	.....	S.C.S.	"		
Foot of Rapids near Mud River	" 30	7 p.m.	28.06	55	E.N.E.	K.S.	Cloudy.		
" "	July 1	6 a.m.	28.15	49	41	K.S.	Overcast.		
Two miles below mouth of Mud River	" 1	7 p.m.	28.02	64	51	S.W.	"		
Mountain Portage, Liard River	" 2	6 a.m.	28.04	51	40	.....	K.S.		
" 3	8 p.m.	28.00	57	47	E.N.E.	C.K.S.	Temp. of water, 52°.		
Mountain Portage, Liard River	" 3	6 a.m.	28.07	47	45	.....	N.		
Second Portage, Liard River	" 4	7 p.m.	28.06	57	51	.....	Clear.		
" 4	6 a.m.	28.05	42	34	.....	C.K.S.	Thunder showers.		
Head Portage Brule	" 4	10 p.m.	28.00	50	40	.....	Cloudy.		
" 5	6 a.m.	28.15	52	40	.....	N.	Cleared up during night.		
Head Portage Brule	" 5	5 p.m.	28.25	53	47	W.	Showery.		
" 6	6 a.m.	28.35	56	41	W.	K.S.	Shower weather.		
" 6	7 p.m.	28.26	58	37	.....	C.K.S.	Cloudy.		
Foot Portage Brule	" 7	6 a.m.	28.30	52	S.W.	S.C.S.	Tom. of water, 51° 30'.		
" 8	6 a.m.	28.25	46	33	W.S.W.	K.S.	Thunder showers all day.		
					S.E.	C.K.S.	Heavy thunder showers at noon.		

* bar, used from this on reads .165 lower than the one previously read.

LOCALITY.	Date.	Hour.	Bar.	Therm.	Air.	Min.	Wind.	Clouds.	Weather at time.	REMARKS.
Fort Liard, 20 ft. above river level	Aug. 2	7 P.M.	29.18	50	°	48	N.	N. K.S. K.R.S. S.K. S.K.S.	Raining, overcast, cloudy.	Water falling in river.
"	"	7 A.M.	29.38	53	°	54	E.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	4	8 A.M.	29.26	67	°	52	S.W.	N. K.S. K.R.S. S.K. S.K.S.	"	Ten of water, 57°.
"	4	6 A.M.	29.16	61	°	52	S.W.	N. K.S. K.R.S. S.K. S.K.S.	"	Passing showers.
"	4	7 P.M.	29.03	64	°	46	S.W.	N. K.S. K.R.S. S.K. S.K.S.	"	Raining in afternoon.
"	5	6 A.M.	28.98	52	°	46	S.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	5	7 P.M.	28.93	51	°	44	S.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	6	6 A.M.	28.73	52	°	44	S.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	6	8 P.M.	28.45	52	°	44	S.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	7	4 A.M.	29.48	48	°	44	S.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	7	9 P.M.	29.42	49	°	44	S.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	8	5 A.M.	29.30	50	°	47	S.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	8	8 P.M.	28.97	55	°	51	S.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	9	4 A.M.	28.87	51	°	50	S.E.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	9	9 P.M.	29.32	62	°	52	N.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	10	8 A.M.	29.32	56	°	52	N.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	10	8 P.M.	29.40	62	°	52	N.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	11	7 A.M.	29.49	55	°	44	N.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	11	7 P.M.	29.30	66	°	50	N.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	12	8 A.M.	29.40	52	°	50	N.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	12	8 P.M.	29.50	54	°	44	N.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	13	7 A.M.	29.52	52	°	44	S.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	13	7 P.M.	29.55	56	°	42	S.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	14	8 A.M.	29.60	51	°	42	S.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	14	8 P.M.	29.30	62	°	36	N.N.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
"	15	6 A.M.	29.22	58	°	40	N.N.W.	N. K.S. K.R.S. S.K. S.K.S.	"	"
On H. B. steamer	25	4 P.M.	25.45	44	°	40	no observations taken	S.C.S.	Overcast, cloudy.	Passing showers.
On H. B. steamer	26	7 P.M.	25.33	46	°	45	S.E.	S.C.S.	"	"
"	26	7 A.M.	29.17	64	°	50	S.E.	S.C.S.	"	"
"	26	8 P.M.	29.17	64	°	50	S.E.	S.C.S.	"	"
"	27	8 A.M.	28.94	68	°	50	S.E.	S.C.S.	"	"
"	27	8 P.M.	28.93	66	°	50	S.E.	S.C.S.	"	"
"	28	8 A.M.	28.82	58	°	50	N.E.	S.C.S.	"	"
"	28	8 P.M.	28.84	54	°	50	N.E.	S.C.S.	"	"
"	29	8 A.M.	29.10	61	°	53	N.	C.G.S.	"	"
"	29	8 P.M.	29.25	53	°	53	N.	C.G.S.	"	"
"	30	8 A.M.	29.30	54	°	53	S.S.W.	N. C.G.S.	"	"
"	30	8 P.M.	29.30	51	°	50	S.E.	N. C.G.S.	"	"
Below Pointe Saul, Slave River	31	5 A.M.	29.25	56	°	54	S.W.	S.W. C.G.S.	"	"
Below Pointe Saul, Slave River	31	5 P.M.	29.25	56	°	54	S.W.	S.W. C.G.S.	"	"
On Fort Resolution	31	8 P.M.	29.25	56	°	54	S.W.	S.W. C.G.S.	"	"

LOCALITY.	Date.	Hour.	Bar.	Therm.		Wind.	Clouds.	Weather at time.	REMARKS.
				Air.	Min.				
1887.									
Mouth of Willow River	Sept. 26	7 P.m.	29.30	42	36	N.N.W.	C.S.	Raining in afternoon.	
"	" 27	6 a.m.	29.22	38	35	E.N.E.	C.S.	Cloudy.	
"	" 27	7 P.m.	29.32	38	35	E.N.E.	C.S.	Fog.	
"	" 28	6 a.m.	29.25	25	25	E.N.E.	C.S.	Cloudy.	
"	" 28	7 P.m.	28.88	40	39	S.E.	C.S.	Clear at noon.	
"	" 29	6 a.m.	28.30	39	39	N.E.	C.S.	Clearing.	
"	" 29	7 P.m.	29.39	42	38	N.E.	C.S.	Raining.	
"	" 30	6 a.m.	29.70	38	38	N.E.	C.S.	Cloudy.	
"	" 30	8 P.m.	28.89	40	38	N.N.E.	C.S.	Overcast.	
"	" 30	6 a.m.	29.10	35	34	N.N.E.	C.S.	Raining.	
Oct.									
"	1	8 P.m.	29.45	36	35	N.N.E.	C.S.	Snowing.	
"	1	9 a.m.	29.65	29	28	N.N.E.	C.S.	At 11.	
"	1	2 P.m.	29.65	22	17	N.E.	C.S.	Overcast.	
"	1	8 P.m.	29.58	15	15	E.N.E.	C.S.	At 4.	
"	2	9 a.m.	29.55	15	15	E.N.E.	C.S.	At 4.	
"	2	8 P.m.	29.51	34	30	N.E.	C.S.	At 4.	
Fort Providence	" 4	8 P.m.	29.51	30	30	.....	.....	.....	.....

METEOROLOGICAL OBSERVATIONS AT FORT PROVIDENCE, SEASON 1888-9.

Date.	Hour.	Bar.	Thermometer.			Wind.		Clouds.	Weather at time.	REMARKS.
			Air.	Max.	Min.	Direction.	Force.			
1887.	8 p.m.	29.32	39	.....	.....	N.E.	.....	S.	.....	Some rain in afternoon.
Oct. 4	9 a.m.	29.43	33	.....	33	N.E.	.....	N.	.....	Clearing.
4	5	29.52	33	.....	.....	N.N.E.	.....	S.	.....	"
4	6	29.66	26	.....	21	N.N.E.	.....	S.	.....	"
4	7	29.70	33	41	.....	S.E.	.....	.....	.....	"
4	8	29.63	24	.....	16	E.N.E.	.....	.....	.....	"
4	9	29.63	29	35	.....	E.N.E.	.....	.....	.....	"
4	10	29.44	27	35	25	N.E.	.....	.....	.....	"
4	11	29.45	33	38	.....	N.E.	.....	.....	.....	"
4	12	29.80	34	31	.....	W.N.W.	.....	.....	.....	"
4	13	29.90	33	36	.....	W.N.W.	.....	.....	.....	"
4	14	29.90	37	35	.....	E.	.....	.....	.....	"
4	15	29.61	33	35	.....	E.	.....	.....	.....	"
4	16	29.00	33	33	.....	S.W.	.....	.....	.....	"
4	17	29.00	30	34	.....	N.W.	.....	.....	.....	"
4	18	29.50	31	35	29	W.	.....	.....	.....	"
4	19	29.50	31	35	29	.....	.....	.....	.....	"
4	20	29.65	31	35	25	N.W.	.....	.....	.....	"
4	21	29.50	35	35	25	.....	.....	.....	.....	"
4	22	29.65	31	35	32	N.W.	.....	.....	.....	"
4	23	28.95	32	32	32	W.W.	.....	.....	.....	"
4	24	29.25	33	35	32	N.W.	.....	.....	.....	"
4	25	29.20	33	34	32	N.E.	.....	.....	.....	"
4	26	29.40	33	34	31	W.W.	.....	.....	.....	"
4	27	29.51	32	33	34	N.N.W.	.....	.....	.....	"
4	28	29.42	32	33	31	N.E.	.....	.....	.....	"
4	29	29.75	32	32	32	N.E.	.....	.....	.....	"
4	30	29.15	32	32	31	N.E.	.....	.....	.....	"
4	31	28.80	30	30	29	.....	.....	.....	.....	"
4	32	29.06	28	27	33	.....	.....	.....	.....	"
4	33	29.42	28	28	24	W.N.W.	.....	.....	.....	"
4	34	29.47	32	35	18	S.W.	.....	.....	.....	"
4	35	29.49	29	29	31	.....	.....	.....	.....	"
4	36	29.49	29	29	29	.....	.....	.....	.....	"
4	37	29.85	8	8	8	.....	.....	.....	.....	"
4	38	29.98	10	11	11	.....	.....	.....	.....	"
4	39	29.21	5	5	2	.....	.....	.....	.....	"
4	40	30.31	7	9	3	.....	.....	.....	.....	"
4	41	30.30	7	9	9	.....	.....	.....	.....	"
4	42	30.14	8	9	8	W.N.W.	.....	.....	.....	"

METEOROLOGICAL OBSERVATIONS AT FORT PROVINCIAL—Continued

Date.	Hour.	Bar.	Thermometer.	Wind.	Clouds.	Weather at time.	REMARKS.
			Air. Max. Min.	Direction.	Force.	Kind.	Amt.
1857.	24	9 a.m.	29 60	E. -3	1	S.	Clear.
	24	5 p.m.	29 61	N.E.	1	NE.	Overcast.
	25	9 a.m.	29 67	E.N.E.	1	NE.	Cloudy and cold.
	25	5 p.m.	29 55	E.E.	1	E.	Clear.
	26	9 a.m.	29 35	E.S.E.	1	E.	Overcast.
	26	5 p.m.	29 38	E.S.E.	1	E.	Cloudy.
	27	9 a.m.	29 23	E.S.E.	1	E.	Cloudy.
	27	5 p.m.	29 23	E.S.E.	1	E.	Cloudy.
	28	9 a.m.	29 33	E.	1	E.	Cloudy.
	28	5 p.m.	29 34	E.	1	E.	Cloudy.
	29	9 a.m.	29 36	E.	1	E.	Cloudy.
	29	5 p.m.	29 32	E.	1	E.	Cloudy.
	30	9 a.m.	29 42	E.	1	E.	Cloudy.
	30	5 p.m.	29 41	E.	1	E.	Cloudy.
	31	9 a.m.	29 16	E.	1	E.	Cloudy.
	31	5 p.m.	29 15	E.	1	E.	Cloudy.
	1	9 a.m.	29 57	E.	1	E.	Cloudy.
	1	5 p.m.	29 57	E.	1	E.	Cloudy.
	2	9 a.m.	29 91	E.	1	E.	Cloudy.
	2	5 p.m.	29 91	E.	1	E.	Cloudy.
	3	9 a.m.	29 54	E.	1	E.	Cloudy.
	3	5 p.m.	29 54	E.	1	E.	Cloudy.
	4	9 a.m.	29 56	E.	1	E.	Cloudy.
	4	5 p.m.	29 56	E.	1	E.	Cloudy.
	5	9 a.m.	29 46	E.	1	E.	Cloudy.
	5	5 p.m.	29 45	E.	1	E.	Cloudy.
	6	9 a.m.	29 47	E.	1	E.	Cloudy.
	6	5 p.m.	29 47	E.	1	E.	Cloudy.
	7	9 a.m.	29 26	E.	1	E.	Cloudy.
	7	5 p.m.	29 26	E.	1	E.	Cloudy.
	8	9 a.m.	29 30	E.	1	E.	Cloudy.
	8	5 p.m.	29 30	E.	1	E.	Cloudy.
	9	9 a.m.	29 31	E.	1	E.	Cloudy.
	9	5 p.m.	29 31	E.	1	E.	Cloudy.
	10	9 a.m.	29 32	E.	1	E.	Cloudy.
	10	5 p.m.	29 32	E.	1	E.	Cloudy.
	11	9 a.m.	29 34	E.	1	E.	Cloudy.
	11	5 p.m.	29 34	E.	1	E.	Cloudy.
	12	9 a.m.	29 35	E.	1	E.	Cloudy.
	12	5 p.m.	29 35	E.	1	E.	Cloudy.
	13	9 a.m.	29 36	E.	1	E.	Cloudy.
	13	5 p.m.	29 36	E.	1	E.	Cloudy.
	14	9 a.m.	29 37	E.	1	E.	Cloudy.
	14	5 p.m.	29 37	E.	1	E.	Cloudy.
	15	9 a.m.	29 38	E.	1	E.	Cloudy.
	15	5 p.m.	29 38	E.	1	E.	Cloudy.
	16	9 a.m.	29 39	E.	1	E.	Cloudy.
	16	5 p.m.	29 39	E.	1	E.	Cloudy.
	17	9 a.m.	29 40	E.	1	E.	Cloudy.
	17	5 p.m.	29 40	E.	1	E.	Cloudy.
	18	9 a.m.	29 41	E.	1	E.	Cloudy.
	18	5 p.m.	29 41	E.	1	E.	Cloudy.
	19	9 a.m.	29 42	E.	1	E.	Cloudy.
	19	5 p.m.	29 42	E.	1	E.	Cloudy.
	20	9 a.m.	29 43	E.	1	E.	Cloudy.
	20	5 p.m.	29 43	E.	1	E.	Cloudy.
	21	9 a.m.	29 44	E.	1	E.	Cloudy.
	21	5 p.m.	29 44	E.	1	E.	Cloudy.
	22	9 a.m.	29 45	E.	1	E.	Cloudy.
	22	5 p.m.	29 45	E.	1	E.	Cloudy.
	23	9 a.m.	29 46	E.	1	E.	Cloudy.
	23	5 p.m.	29 46	E.	1	E.	Cloudy.
	24	9 a.m.	29 47	E.	1	E.	Cloudy.
	24	5 p.m.	29 47	E.	1	E.	Cloudy.
	25	9 a.m.	29 48	E.	1	E.	Cloudy.
	25	5 p.m.	29 48	E.	1	E.	Cloudy.
	26	9 a.m.	29 49	E.	1	E.	Cloudy.
	26	5 p.m.	29 49	E.	1	E.	Cloudy.
	27	9 a.m.	29 50	E.	1	E.	Cloudy.
	27	5 p.m.	29 50	E.	1	E.	Cloudy.
	28	9 a.m.	29 51	E.	1	E.	Cloudy.
	28	5 p.m.	29 51	E.	1	E.	Cloudy.
	29	9 a.m.	29 52	E.	1	E.	Cloudy.
	29	5 p.m.	29 52	E.	1	E.	Cloudy.
	30	9 a.m.	29 53	E.	1	E.	Cloudy.
	30	5 p.m.	29 53	E.	1	E.	Cloudy.
	31	9 a.m.	29 54	E.	1	E.	Cloudy.
	31	5 p.m.	29 54	E.	1	E.	Cloudy.
	1	9 a.m.	29 55	E.	1	E.	Cloudy.
	1	5 p.m.	29 55	E.	1	E.	Cloudy.
	2	9 a.m.	29 56	E.	1	E.	Cloudy.
	2	5 p.m.	29 56	E.	1	E.	Cloudy.
	3	9 a.m.	29 57	E.	1	E.	Cloudy.
	3	5 p.m.	29 57	E.	1	E.	Cloudy.
	4	9 a.m.	29 58	E.	1	E.	Cloudy.
	4	5 p.m.	29 58	E.	1	E.	Cloudy.
	5	9 a.m.	29 59	E.	1	E.	Cloudy.
	5	5 p.m.	29 59	E.	1	E.	Cloudy.
	6	9 a.m.	29 60	E.	1	E.	Cloudy.
	6	5 p.m.	29 60	E.	1	E.	Cloudy.
	7	9 a.m.	29 61	E.	1	E.	Cloudy.
	7	5 p.m.	29 61	E.	1	E.	Cloudy.
	8	9 a.m.	29 62	E.	1	E.	Cloudy.
	8	5 p.m.	29 62	E.	1	E.	Cloudy.
	9	9 a.m.	29 63	E.	1	E.	Cloudy.
	9	5 p.m.	29 63	E.	1	E.	Cloudy.
	10	9 a.m.	29 64	E.	1	E.	Cloudy.
	10	5 p.m.	29 64	E.	1	E.	Cloudy.
	11	9 a.m.	29 65	E.	1	E.	Cloudy.
	11	5 p.m.	29 65	E.	1	E.	Cloudy.
	12	9 a.m.	29 66	E.	1	E.	Cloudy.
	12	5 p.m.	29 66	E.	1	E.	Cloudy.
	13	9 a.m.	29 67	E.	1	E.	Cloudy.
	13	5 p.m.	29 67	E.	1	E.	Cloudy.
	14	9 a.m.	29 68	E.	1	E.	Cloudy.
	14	5 p.m.	29 68	E.	1	E.	Cloudy.
	15	9 a.m.	29 69	E.	1	E.	Cloudy.
	15	5 p.m.	29 69	E.	1	E.	Cloudy.
	16	9 a.m.	29 70	E.	1	E.	Cloudy.
	16	5 p.m.	29 70	E.	1	E.	Cloudy.
	17	9 a.m.	29 71	E.	1	E.	Cloudy.
	17	5 p.m.	29 71	E.	1	E.	Cloudy.
	18	9 a.m.	29 72	E.	1	E.	Cloudy.
	18	5 p.m.	29 72	E.	1	E.	Cloudy.
	19	9 a.m.	29 73	E.	1	E.	Cloudy.
	19	5 p.m.	29 73	E.	1	E.	Cloudy.
	20	9 a.m.	29 74	E.	1	E.	Cloudy.
	20	5 p.m.	29 74	E.	1	E.	Cloudy.
	21	9 a.m.	29 75	E.	1	E.	Cloudy.
	21	5 p.m.	29 75	E.	1	E.	Cloudy.
	22	9 a.m.	29 76	E.	1	E.	Cloudy.
	22	5 p.m.	29 76	E.	1	E.	Cloudy.
	23	9 a.m.	29 77	E.	1	E.	Cloudy.
	23	5 p.m.	29 77	E.	1	E.	Cloudy.
	24	9 a.m.	29 78	E.	1	E.	Cloudy.
	24	5 p.m.	29 78	E.	1	E.	Cloudy.
	25	9 a.m.	29 79	E.	1	E.	Cloudy.
	25	5 p.m.	29 79	E.	1	E.	Cloudy.
	26	9 a.m.	29 80	E.	1	E.	Cloudy.
	26	5 p.m.	29 80	E.	1	E.	Cloudy.
	27	9 a.m.	29 81	E.	1	E.	Cloudy.
	27	5 p.m.	29 81	E.	1	E.	Cloudy.
	28	9 a.m.	29 82	E.	1	E.	Cloudy.
	28	5 p.m.	29 82	E.	1	E.	Cloudy.
	29	9 a.m.	29 83	E.	1	E.	Cloudy.
	29	5 p.m.	29 83	E.	1	E.	Cloudy.
	30	9 a.m.	29 84	E.	1	E.	Cloudy.
	30	5 p.m.	29 84	E.	1	E.	Cloudy.
	31	9 a.m.	29 85	E.	1	E.	Cloudy.
	31	5 p.m.	29 85	E.	1	E.	Cloudy.
	1	9 a.m.	29 86	E.	1	E.	Cloudy.
	1	5 p.m.	29 86	E.	1	E.	Cloudy.
	2	9 a.m.	29 87	E.	1	E.	Cloudy.
	2	5 p.m.	29 87	E.	1	E.	Cloudy.
	3	9 a.m.	29 88	E.	1	E.	Cloudy.
	3	5 p.m.	29 88	E.	1	E.	Cloudy.
	4	9 a.m.	29 89	E.	1	E.	Cloudy.
	4	5 p.m.	29 89	E.	1	E.	Cloudy.
	5	9 a.m.	29 90	E.	1	E.	Cloudy.
	5	5 p.m.	29 90	E.	1	E.	Cloudy.
	6	9 a.m.	29 91	E.	1	E.	Cloudy.
	6	5 p.m.	29 91	E.	1	E.	Cloudy.
	7	9 a.m.	29 92	E.	1	E.	Cloudy.
	7	5 p.m.	29 92	E.	1	E.	Cloudy.
	8	9 a.m.	29 93	E.	1	E.	Cloudy.
	8	5 p.m.	29 93	E.	1	E.	Cloudy.
	9	9 a.m.	29 94	E.	1	E.	Cloudy.
	9	5 p.m.	29 94	E.	1	E.	Cloudy.
	10	9 a.m.	29 95	E.	1	E.	Cloudy.
	10	5 p.m.	29 95	E.	1	E.	Cloudy.
	11	9 a.m.	29 96	E.	1	E.	Cloudy.
	11	5 p.m.	29 96	E.	1	E.	Cloudy.
	12	9 a.m.	29 97	E.	1	E.	Cloudy.
	12	5 p.m.	29 97	E.	1	E.	Cloudy.
	13	9 a.m.	29 98	E.	1	E.	Cloudy.
	13	5 p.m.	29 98	E.	1	E.	Cloudy.
	14	9 a.m.	29 99	E.	1	E.	Cloudy.
	14	5 p.m.	29 99	E.	1	E.	Cloudy.
	15	9 a.m.	29 100	E.	1	E.	Cloudy.
	15	5 p.m.	29 100	E.	1	E.	Cloudy.
	16	9 a.m.	29 101	E.	1	E.	Cloudy.
	16	5 p.m.	29 101	E.	1	E.	Cloudy.
	17	9 a.m.	29 102	E.	1	E.	Cloudy.
	17	5 p.m.	29 102	E.	1	E.	Cloudy.
	18	9 a.m.	29 103	E.	1	E.	Cloudy.
	18	5 p.m.	29 103	E.	1	E.	Cloudy.
	19	9 a.m.	29 104	E.	1	E.	Cloudy.
	19	5 p.m.	29 104	E.	1	E.	Cloudy.
	20	9 a.m.	29 105	E.	1	E.	Cloudy.
	20	5 p.m.	29 105	E.	1	E.	Cloudy.
	21	9 a.m.	29 106	E.	1	E.	Cloudy.
	21	5 p.m.	29 106	E.	1	E.	Cloudy.
	22	9 a.m.	29 107	E.	1	E.	Cloudy.
	22	5 p.m.	29 107	E.	1	E.	Cloudy.
	23	9 a.m.	29 108	E.	1	E.	Cloudy.
	23	5 p.m.	29 108	E.	1	E.	Cloudy.
	24	9 a.m.	29 109	E.	1	E.	Cloudy.
	24	5 p.m.	29 109	E.	1	E.	Cloudy.
	25	9 a.m.	29 110	E.	1	E.	Cloudy.
	25	5 p.m.	29 110	E.	1	E.	Cloudy.
	26	9 a.m.	29 111	E.	1	E.	Cloudy.
	26	5 p.m.	29 111	E.	1	E.	Cloudy.
	27	9 a.m.	29 112	E.	1	E.	Cloudy.
	27	5 p.m.	29 112	E.	1	E.	Cloudy.
	28	9 a.m.	29 113	E.	1	E.	Cloudy.
	28	5 p.m.	29 113	E.	1	E.	Cloudy.
	29	9 a.m.	29 114	E.	1	E.	Cloudy.
	29	5 p.m.	29 114	E.	1	E.	Cloudy.
	30	9 a.m.	29 115	E.	1	E.	Cloudy.
	30	5 p.m.	29 115	E.	1	E.	Cloudy.
	31	9 a.m.	29 116	E.	1	E.	Cloudy.
	31	5 p.m.	29 116	E.	1	E.	Cloudy.
	1	9 a.m.	29 117	E.	1	E.	Cloudy.
	1	5 p.m.	29 117	E.	1	E.	Cloudy.
	2	9 a.m.	29 118	E.	1	E.	Cloudy.
	2	5 p.m.	29 118	E.	1	E.	Cloudy.
	3	9 a.m.	29 119	E.	1	E.	Cloudy.
	3	5 p.m.	29 119	E.	1	E.	Cloudy.
	4	9 a.m.	29 120	E.	1	E.	Cloudy.
	4	5 p.m.	29 120	E.	1	E.	Cloudy.
	5	9 a.m.	29 121	E.	1	E.	Cloudy.
	5	5 p.m.	29 121	E.	1	E.	Cloudy.
	6	9 a.m.	29 122	E.	1	E.	Cloudy.
	6	5 p.m					

METEOROLOGICAL OBSERVATIONS AT FORT PROVIDENCE.—*Continued.*

METEOROLOGICAL OBSERVATIONS AT FORT PROVIDENCE—Continued.

Date.	Hour.	Bar.	Thermometer.			Wind.		Clouds.	Kind.	Amt.	Weather at time.	REMARKS.
			Air.	Max.	Min.	Direction.	Force.					
1888.												
Jan. 20	5 p.m.	29.50	5	5	—21	N. N. N. W.	1					
21	9 a.m.	—20	3	—3	—38	N. N. W.	1					
21	5 p.m.	—23	2	—22	—22	.....	.....			
22	9 a.m.	—23	2	—22	—22	.....	.....			
22	5 p.m.	—23	2	—22	—22	.....	.....			
23	9 a.m.	—23	2	—22	—22	.....	.....			
23	5 p.m.	—23	2	—22	—22	.....	.....			
24	9 a.m.	—24	2	—22	—22	.....	.....			
24	5 p.m.	—24	2	—22	—22	.....	.....			
25	9 a.m.	—25	2	—22	—22	S.E.	1					
25	5 p.m.	—25	2	—22	—22	E.	1					
26	9 a.m.	—26	2	—22	—22	E.	1					
26	5 p.m.	—26	2	—22	—22	E.	1					
27	9 a.m.	—26	2	—22	—22	S.E.	1					
27	5 p.m.	—27	2	—22	—22	E.	1					
28	9 a.m.	—27	2	—22	—22	E.	1					
28	5 p.m.	—27	2	—22	—22	E.	1					
29	9 a.m.	—28	2	—22	—22	E.	1					
29	5 p.m.	—28	2	—22	—22	E.	1					
30	9 a.m.	—29	2	—22	—22	N.	1					
30	5 p.m.	—29	2	—22	—22	N.	1					
31	9 a.m.	—30	2	—22	—22	N.	2					
31	5 p.m.	—30	2	—22	—22	N.	1					
Feb. 1	9 a.m.	—31	2	—22	—22	W.	1					
1	5 p.m.	—31	2	—22	—22	W.	2					
2	9 a.m.	—32	2	—22	—22	E.	2					
2	5 p.m.	—32	2	—22	—22	E.	2					
3	9 a.m.	—32	2	—22	—22	E.	2					
3	5 p.m.	—32	2	—22	—22	E.	2					
4	9 a.m.	—33	2	—22	—22	W.	1					
4	5 p.m.	—33	2	—22	—22	W.	1					
5	9 a.m.	—34	2	—22	—22	W.	2					
5	5 p.m.	—34	2	—22	—22	W.	2					
6	9 a.m.	—34	2	—22	—22	W.	2					
6	5 p.m.	—34	2	—22	—22	W.	2					
7	9 a.m.	—34	2	—22	—22	W.	2					
7	5 p.m.	—34	2	—22	—22	W.	2					
8	9 a.m.	—34	2	—22	—22	W.	2					
8	5 p.m.	—34	2	—22	—22	W.	2					
9	9 a.m.	—34	2	—22	—22	W.	2					
9	5 p.m.	—34	2	—22	—22	W.	2					
10	9 a.m.	—34	2	—22	—22	W.	2					
10	5 p.m.	—34	2	—22	—22	W.	2					
11	9 a.m.	—34	2	—22	—22	W.	2					
11	5 p.m.	—34	2	—22	—22	W.	2					
12	9 a.m.	—34	2	—22	—22	W.	2					
12	5 p.m.	—34	2	—22	—22	W.	2					
13	9 a.m.	—34	2	—22	—22	W.	2					
13	5 p.m.	—34	2	—22	—22	W.	2					
14	9 a.m.	—34	2	—22	—22	W.	2					
14	5 p.m.	—34	2	—22	—22	W.	2					
15	9 a.m.	—34	2	—22	—22	W.	2					
15	5 p.m.	—34	2	—22	—22	W.	2					
16	9 a.m.	—34	2	—22	—22	W.	2					
16	5 p.m.	—34	2	—22	—22	W.	2					
17	9 a.m.	—34	2	—22	—22	W.	2					
17	5 p.m.	—34	2	—22	—22	W.	2					
18	9 a.m.	—34	2	—22	—22	W.	2					
18	5 p.m.	—34	2	—22	—22	W.	2					
19	9 a.m.	—34	2	—22	—22	W.	2					
19	5 p.m.	—34	2	—22	—22	W.	2					
20	9 a.m.	—34	2	—22	—22	W.	2					
20	5 p.m.	—34	2	—22	—22	W.	2					
21	9 a.m.	—34	2	—22	—22	W.	2					
21	5 p.m.	—34	2	—22	—22	W.	2					
22	9 a.m.	—34	2	—22	—22	W.	2					
22	5 p.m.	—34	2	—22	—22	W.	2					
23	9 a.m.	—34	2	—22	—22	W.	2					
23	5 p.m.	—34	2	—22	—22	W.	2					
24	9 a.m.	—34	2	—22	—22	W.	2					
24	5 p.m.	—34	2	—22	—22	W.	2					
25	9 a.m.	—34	2	—22	—22	W.	2					
25	5 p.m.	—34	2	—22	—22	W.	2					
26	9 a.m.	—34	2	—22	—22	W.	2					
26	5 p.m.	—34	2	—22	—22	W.	2					
27	9 a.m.	—34	2	—22	—22	W.	2					
27	5 p.m.	—34	2	—22	—22	W.	2					
28	9 a.m.	—34	2	—22	—22	W.	2					
28	5 p.m.	—34	2	—22	—22	W.	2					
29	9 a.m.	—34	2	—22	—22	W.	2					
29	5 p.m.	—34	2	—22	—22	W.	2					
30	9 a.m.	—34	2	—22	—22	W.	2					
30	5 p.m.	—34	2	—22	—22	W.	2					
31	9 a.m.	—34	2	—22	—22	W.	2					
31	5 p.m.	—34	2	—22	—22	W.	2					
Feb. 1	9 a.m.	—34	2	—22	—22	W.	2					
1	5 p.m.	—34	2	—22	—22	W.	2					
2	9 a.m.	—34	2	—22	—22	W.	2					
2	5 p.m.	—34	2	—22	—22	W.	2					
3	9 a.m.	—34	2	—22	—22	W.	2					
3	5 p.m.	—34	2	—22	—22	W.	2					
4	9 a.m.	—34	2	—22	—22	W.	2					
4	5 p.m.	—34	2	—22	—22	W.	2					
5	9 a.m.	—34	2	—22	—22	W.	2					
5	5 p.m.	—34	2	—22	—22	W.	2					
6	9 a.m.	—34	2	—22	—22	W.	2					
6	5 p.m.	—34	2	—22	—22	W.	2					
7	9 a.m.	—34	2	—22	—22	W.	2					
7	5 p.m.	—34	2	—22	—22	W.	2					
8	9 a.m.	—34	2	—22	—22	W.	2					
8	5 p.m.	—34	2	—22	—22	W.	2					
9	9 a.m.	—34	2	—22	—22	W.	2					
9	5 p.m.	—34	2	—22	—22	W.	2					
10	9 a.m.	—34	2	—22	—22	W.	2					
10	5 p.m.	—34	2	—22	—22	W.	2					
11	9 a.m.	—34	2	—22	—22	W.	2					
11	5 p.m.	—34	2	—22	—22	W.	2					
12	9 a.m.	—34	2	—22	—22	W.	2					
12	5 p.m.	—34	2	—22	—22	W.	2					
13	9 a.m.	—34	2	—22	—22	W.	2					
13	5 p.m.	—34	2	—22	—22	W.	2					
14	9 a.m.	—34	2	—22	—22	W.	2					
14	5 p.m.	—34	2	—22	—22	W.	2					
15	9 a.m.	—34	2	—22	—22	W.	2					
15	5 p.m.	—34	2	—22	—22	W.	2					
16	9 a.m.	—34	2	—22	—22	W.	2					
16	5 p.m.	—34	2	—22	—22	W.	2					
17	9 a.m.	—34	2	—22	—22	W.	2					
17	5 p.m.	—34	2	—22	—22	W.	2					
18	9 a.m.	—34	2	—22	—22	W.	2					
18	5 p.m.	—34	2	—22	—22	W.	2					
19	9 a.m.	—34	2	—22	—22	W.	2					
19	5 p.m.	—34	2	—22	—22	W.	2					
20	9 a.m.	—34	2	—22	—22	W.	2					
20	5 p.m.	—34	2	—22	—22	W.	2					
21	9 a.m.	—34	2	—22	—22	W.	2					
21	5 p.m.	—34	2	—22	—22	W.	2					
22	9 a.m.	—34	2	—22	—22	W.	2					
22	5 p.m.	—34	2	—22	—22	W.	2					
23	9 a.m.	—34	2	—22	—22	W.	2					
23	5 p.m.	—34	2	—22	—22	W.	2					
24	9 a.m.	—34	2	—22	—22	W.	2					
24	5 p.m.	—34	2	—22	—22	W.	2					
25	9 a.m.	—34	2	—22	—22	W.	2					
25	5 p.m.	—34	2	—22	—22	W.	2					
26	9 a.m.	—34	2	—22	—22	W.	2					
26	5 p.m.	—34	2	—22	—22	W.	2					
27	9 a.m.	—34	2	—22	—22	W.	2					
27	5 p.m.	—34	2	—22	—22	W.	2					
28	9 a.m.	—34	2	—22	—22	W.	2					
28	5 p.m.	—34	2	—22	—22	W.	2					
29	9 a.m.	—34	2	—22	—22	W.	2					
29	5 p.m.	—34	2	—22	—22	W.	2					
30	9 a.m.	—34	2	—22	—22	W.	2					
30	5 p.m.	—34	2	—22	—22	W.	2					
31	9 a.m.	—34	2	—22	—22	W.	2					
31	5 p.m.	—34	2	—22	—22	W.	2					
Feb. 1	9 a.m.	—34	2	—22	—22	W.	2					
1	5 p.m.	—34	2	—22	—22	W.	2					
2	9 a.m.	—34	2	—22	—22	W.	2					
2	5 p.m.	—34	2	—22	—22							

METEOROLOGICAL OBSERVATIONS AT FORT PROVIDENCE.—*Continued.*

Date.	Hour.	Bar.	Thermometer.			Wind.		Clouds.		REMARKS.
			Air.	Max.	Min.	Direction.	Force.	Kind.	Alt.	
1889,	9 a.m.	29.75	4	-11	-2	N.E.	1	S.	8	Cloudy. Snowing 4 p.m. to 2 a.m.
" 5	5 p.m.	29.80	9	-17	-7	N.E.	1	S.C.	10	
" 6	9 a.m.	29.59	3	10	-7	N.	1	S.C.	6	
" 6	6 p.m.	29.69	-2	10	-7	N.	1	S.C.	6	
" 7	9 a.m.	29.93	-1	8	-7	N.	1	S.C.	8	
" 7	5 p.m.	29.95	-13	0	-15	N.	2	S.C.	9	
" 8	9 a.m.	29.95	-17	0	-15	N.E.	2	S.C.	3	
" 8	5 p.m.	30.04	-17	0	-15	N.E.	2	S.C.	4	
" 9	9 a.m.	30.10	-31	-35	-35	N.E.	2	S.C.	6	
" 9	5 p.m.	30.08	-22	-15	-15	E.	1	S.C.	6	
" 10	9 a.m.	30.16	-4	-45	-45	.....	1	S.C.	3	
" 10	5 p.m.	30.10	-26	-20	-20	N.E.	1	S.C.	8	Clear.
" 11	9 a.m.	29.95	-30	-40	-40	E.N.E.	2	S.C.	10	
" 11	5 p.m.	29.90	-17	-15	-15	E.N.E.	2	S.C.	8	Cloudy, overcast.
" 12	9 a.m.	29.75	-22	-25	-25	E.N.E.	2	S.C.	10	
" 12	5 p.m.	29.75	-17	-10	-10	E.N.E.	2	S.C.	10	Cloudy, Snowing, overcast.
" 13	9 a.m.	29.8	-2	-4	-4	E.N.E.	1	S.C.	10	
" 13	5 p.m.	29.8	-9	-9	-9	E.N.E.	1	S.C.	10	
" 14	9 a.m.	29.5	-5	-5	-5	E.	2	S.C.	10	
" 14	5 p.m.	29.5	-10	-10	-10	N.	1	S.C.	10	
" 15	9 a.m.	29.55	-10	-3	-3	E.	2	S.C.	10	
" 15	5 p.m.	29.55	-10	-10	-10	N.	1	S.C.	10	
" 16	9 a.m.	29.4	-10	-4	-4	E.	2	S.C.	10	
" 16	5 p.m.	29.4	-10	-4	-4	E.	2	S.C.	10	
" 17	9 a.m.	29.4	-10	-4	-4	E.	1	S.C.	10	
" 17	5 p.m.	29.4	-10	-4	-4	E.	1	S.C.	10	
" 18	9 a.m.	29.5	-10	-4	-4	E.	1	S.C.	10	
" 18	5 p.m.	29.58	-4	-4	-4	N.W.	2	S.C.	10	
" 19	9 a.m.	29.60	-10	-3	-3	N.W.	2	S.C.	10	
" 19	5 p.m.	29.68	-35	-35	-35	N.W.	2	S.C.	10	
" 20	9 a.m.	29.61	-30	-30	-30	N.W.	2	S.C.	10	
" 20	5 p.m.	29.66	-30	-30	-30	N.W.	2	S.C.	10	
" 21	9 a.m.	29.67	-2	-2	-2	N.E.	1	S.C.	9	
" 21	5 p.m.	29.57	-30	-30	-30	N.E.	1	S.C.	5	
" 22	9 a.m.	29.50	-1	-3	-3	N.E.	1	S.C.	4	
" 22	5 p.m.	29.52	-10	-10	-10	N.E.	1	S.C.	4	
" 23	9 a.m.	29.66	3	-3	-3	E.	1	S.C.	3	
" 23	5 p.m.	29.68	10	15	15	E.	1	Light.	4	
" 24	9 a.m.	29.70	8	14	14	.....	4	.....	2	

		N.E.	E.	Light.
22.32	7	10	-3	
29.60	3	15	4	
29.68	10	15	4	
29.70	8	15	4	

METEOROLOGICAL OBSERVATIONS AT FORT PROVIDENCE—Continued.

Date.	Hour.	Bar.	Thermometer.			Wind.			Clouds.		Weather at time.	Remarks.
			Air.	Max.	Min.	Direction.	Force.	Kind.	Amt.			
ISSS.	5 p.m.	30.00	20	24	—7	N.E.	2	S.C.S.	7	Cloudy.		
April 18	6 a.m.	29.98	8	24	—7	N.E.	1	S.C.S.	8	"		
" 19	5 p.m.	29.87	24	27	—2	N.E.	1	S.C.S.	5	"		
" 20	9 a.m.	29.72	14	27	—2	N.E.	1	S.	2	Overcast.		
" 21	5 p.m.	29.65	20	33	—10	N.E.	2	S.	10	Clear.		
" 21	9 a.m.	29.70	16	33	—10	S.W.	1	S.	6	Cloudy.		
" 21	5 p.m.	29.78	33	34	—31	S.W.	2	R.S.	9	"		
" 22	9 a.m.	29.56	24	31	—6	S.W.	1	N.C.S.	9	"		
" 22	5 p.m.	29.91	39	33	—14	E.	3	S.	10	Overcast.		
" 23	5 a.m.	29.86	18	26	—14	E.	3	S.	10	"		
" 23	5 p.m.	29.85	21	26	—14	N.N.E.	2	S.	10	"		
" 24	9 a.m.	29.99	6	26	—1	N.N.E.	1	S.C.S.	2	Cloudy.		
" 24	5 p.m.	29.80	19	21	—1	N.N.E.	1	C.S.	1	"		
" 25	9 a.m.	29.89	20	22	—8	N.N.E.	1	S.	10	Overcast.		
" 25	5 p.m.	29.78	23	20	—8	E.S.E.	1	N.	10	"		
" 26	9 a.m.	29.97	18	22	—14	N.N.E.	3	N.C.S.	10	Snowing.		
" 26	5 p.m.	30.20	16	22	—1	N.N.E.	1	S.C.S.	8	Cloudy.		
" 27	9 a.m.	30.35	8	21	—1	N.N.E.	1	S.C.S.	7	"		
" 28	5 p.m.	30.37	12	21	—8	E.N.E.	1	S.C.S.	8	"		
" 28	9 a.m.	30.25	10	22	—8	E.N.E.	1	S.	10	Overcast.		
" 29	5 p.m.	30.01	29	23	—1	E.	1	N.	10	Snowing.		
" 29	9 a.m.	29.90	19	22	—12	E.	1	N.	10	Overcast.		

Crane seen.
Barking Crow (*Corypha Americana*) seen.
Above freezing point for first time since Nov. 4.

Heavy white frost last night.

A few flakes of snow.

Snowing 8 a.m. to 10 a.m.

Light snowfall.

METEOROLOGICAL OBSERVATIONS.

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METEOROLOGICAL OBSERVATIONS ON MACKENZIE RIVER, SUMMER 1888.

LOCALITY.	Date.	Hour.	Bar.	Thermometer.			Wind.	Clouds.	Weather at time.	REMARKS.
				Air.	Max.	Min.				
Fort Simpson.....	May 6	9 a.m.	.....	43	.....	39	S.	C.K.	Cloudy.	Canada geese arrived on the 2nd.
"	6	5 p.m.	.....	33	.....	36	S.E.	C.S.K.	"	ducks followed on the 5th, and waves on the 5th.
"	7	9 a.m.	10	.....	38	38	S.E.	S.C.S.	"	"
"	7	5 p.m.	.....	57	.....	60	S.E.	S.C.S.	"	"
"	8	9 a.m.	.....	33	.....	32	S.E.	S.C.S.	"	Beautiful spring weather.
"	8	5 p.m.	.....	56	.....	58	S.E.	S.C.S.	"	"
"	9	9 a.m.	.....	38	.....	34	S.E.	K.S.	"	"
"	9	5 p.m.	.....	46	.....	50	S.E.	K.C.S.	"	"
"	10	9 a.m.	.....	34	.....	32	S.E.	K.C.S.	"	"
"	10	5 p.m.	29	48	.....	34	S.E.	K.C.S.	"	"
"	11	9 a.m.	.....	36	.....	34	S.E.	Light K.	"	Snow disappearing rapidly.
"	11	5 p.m.	.....	34	56	.....	N.W.	C.S.	Cloudy.	"
"	12	9 a.m.	38	.....	34	34	N.W.	C.S.	Cloudy.	"
"	12	5 p.m.	.....	62	59	.....	N.W.	C.S.K.	Cloudy.	"
"	13	9 a.m.	40	.....	36	36	E.	N.	Raining.	"
"	13	5 p.m.	54	56	.....	54	E.	N.	Light rain.	"
"	14	9 a.m.	42	.....	38	38	S.E.	N.	Mackenzie clear of ice below the front.	"
"	14	5 p.m.	50	52	.....	52	N.W.	S.C.	overcast.	"
"	15	9 a.m.	42	.....	42	42	N.W.	N.	Cloudy.	"
"	15	5 p.m.	54	.....	54	54	N.W.	S.C.	Clear.	"
"	16	9 a.m.	40	.....	40	40	N.W.	N.	Cloudy.	"
"	16	5 p.m.	48	.....	48	48	N.W.	S.C.	Bright spring weather.	"
"	17	9 a.m.	41	.....	41	44	N.W.	C.S.	"	"
"	17	5 p.m.	43	.....	43	44	N.W.	C.S.	"	"
"	18	9 a.m.	40	.....	46	53	N.	C.S.K.	"	"
"	18	5 p.m.	24	80	38	51	N.E.	S.C.S.K.	"	"
"	19	9 a.m.	21	75	38	51	E.N.E.	Light S.	Overcast.	"
"	19	5 p.m.	20	87	32	32	N.E.	S.	"	"
"	20	9 a.m.	24	87	34	34	N.E.	S.	"	"
"	20	5 p.m.	29	87	32	32	N.E.	S.	"	"
"	21	9 a.m.	29	82	32	32	N.E.	S.	"	"
"	21	5 p.m.	29	75	37	42	N.	C.S.K.	Cloudy.	"
"	22	9 a.m.	29	70	33	44	N.E.	S.C.S.K.	"	"
"	22	5 p.m.	29	65	40	44	N.E.	S.C.S.K.	"	"
"	23	9 a.m.	27	75	39	40	E.S.E.	2	Overcast.	"
"	23	5 p.m.	29	56	35	40	E.S.E.	3	"	"
"	24	9 a.m.	29	56	30	42	E.S.E.	2	Show gone, with the exception of a few patches in sheltered spots.	"
"	24	5 p.m.	28	46	40	42	E.S.E.	2	Showing cloudy.	"
"	25	9 a.m.	29	52	33	30	E.	Light S.C.S.K.	Three inches of snow.	"

LOCALITY.	Date.	Hour.	Bar.	Thermometer.		Wind.		Clouds.	Weather at time.	REMARKS.
				Air.	Max.	Min.	Direction.			
Fort Simpson	May 25	5 P.M.	29.55	42	33	30	E.	C.S.K.	Cloudy.	
	26	9 A.M.	29.55	53	37	33	N.N.E.	S.C.S.	"	
	26	5 P.M.	29.55	53	37	33	N.N.E.	S.C.S.	"	
	27	9 A.M.	29.49	40	33	33	N.E.	C.S.K.	Overcast.	
	27	5 P.M.	29.08	49	33	40	N.E.	C.S.K.	Cloudy.	
	28	9 A.M.	29.44	45	33	40	N.E.	C.S.K.	Rainning.	
	28	5 P.M.	29.25	52	32	38	N.E.	S.C.S.	Cloudy.	
	29	5 P.M.	29.25	53	32	38	N.N.E.	K.S.K.	Overcast.	
	29	9 P.M.	29.55	53	37	37	N.N.E.	K.S.K.	Cloudy.	
	30	5 A.M.	29.15	38	33	33	E.	C.G.S.	Raining.	
	30	9 A.M.	29.15	38	33	33	E.	C.G.S.	Gloomy.	
	31	5 A.M.	29.91	37	30	30	E.	N.C.S.	"	
	31	9 A.M.	29.91	37	30	30	E.	N.C.S.	"	
	June 1	3 P.M.	29.15	44	33	33	E.	N.C.S.	"	
	1	6 A.M.	29.69	40	33	33	S.S.W.	S.C.S.	"	
	1	7 P.M.	29.15	41	33	33	S.E.	C.S.K.	"	
	2	6 A.M.	29.15	45	33	33	S.E.	K.S.K.	Overcast.	
	2	7 P.M.	29.15	45	33	33	S.E.	K.S.K.	Cloudy.	
	3	6 A.M.	29.15	38	33	33	E.	N.C.S.	Overcast.	
	3	6 P.M.	29.69	40	33	33	E.	N.C.S.	Raining.	
	4	6 A.M.	29.91	37	30	30	E.	N.C.S.	Cloudy.	
	4	6 P.M.	30.04	41	33	33	N.	S.C.S.	Overcast.	
	5	6 A.M.	30.16	34	33	33	N.	S.C.S.	Cloudy.	
	5	6 P.M.	30.24	37	33	33	E.	K.S.S.	Cloudy.	
	6	6 A.M.	30.30	35	33	33	E.	S.C.S.	Cloudy.	
	6	6 P.M.	30.29	43	33	33	E.	S.C.S.	Cloudy.	
	7	6 A.M.	30.44	36	33	33	E.	S.C.S.	Cloudy.	
	7	6 P.M.	30.44	36	33	33	E.	S.C.S.	Cloudy.	
	8	6 A.M.	30.44	51	33	33	N.	K.C.S.	Cloudy.	
	8	6 P.M.	30.44	51	33	33	N.	K.C.S.	"	
	9	6 A.M.	30.05	43	33	40	N.	K.C.S.	"	
	9	6 P.M.	30.15	65	33	40	N.E.	K.C.S.	"	
	10	6 A.M.	29.40	54	33	40	N.E.	S.C.S.	"	
	10	6 P.M.	29.85	65	33	43	N.	S.C.S.	Overcast.	
	11	6 A.M.	29.75	47	33	33	N.	K.C.S.	Cloudy.	
	11	6 P.M.	29.72	53	33	33	N.	S.C.S.	"	
	12	6 A.M.	29.76	40	33	33	N.	S.C.S.	"	
	12	6 P.M.	29.80	45	33	33	E.	C.S.K.	"	
	13	6 A.M.	29.55	42	33	35	E.	C.S.K.	"	
	13	6 P.M.	29.50	40	33	40	E.	C.S.K.	"	
	14	6 A.M.	29.78	48	33	40	E.	C.S.K.	"	
	14	6 P.M.	29.63	49	33	43	E.	S.C.K.	"	
Hill by River Side .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Twenty miles below Hill by River Side .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Lat 62° 51' N., Mackenzie River .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Opposite Roche Clark .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Twenty miles above Fort Norman .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fort Norman .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Seventy .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Five miles below Fort Norman .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fifty .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

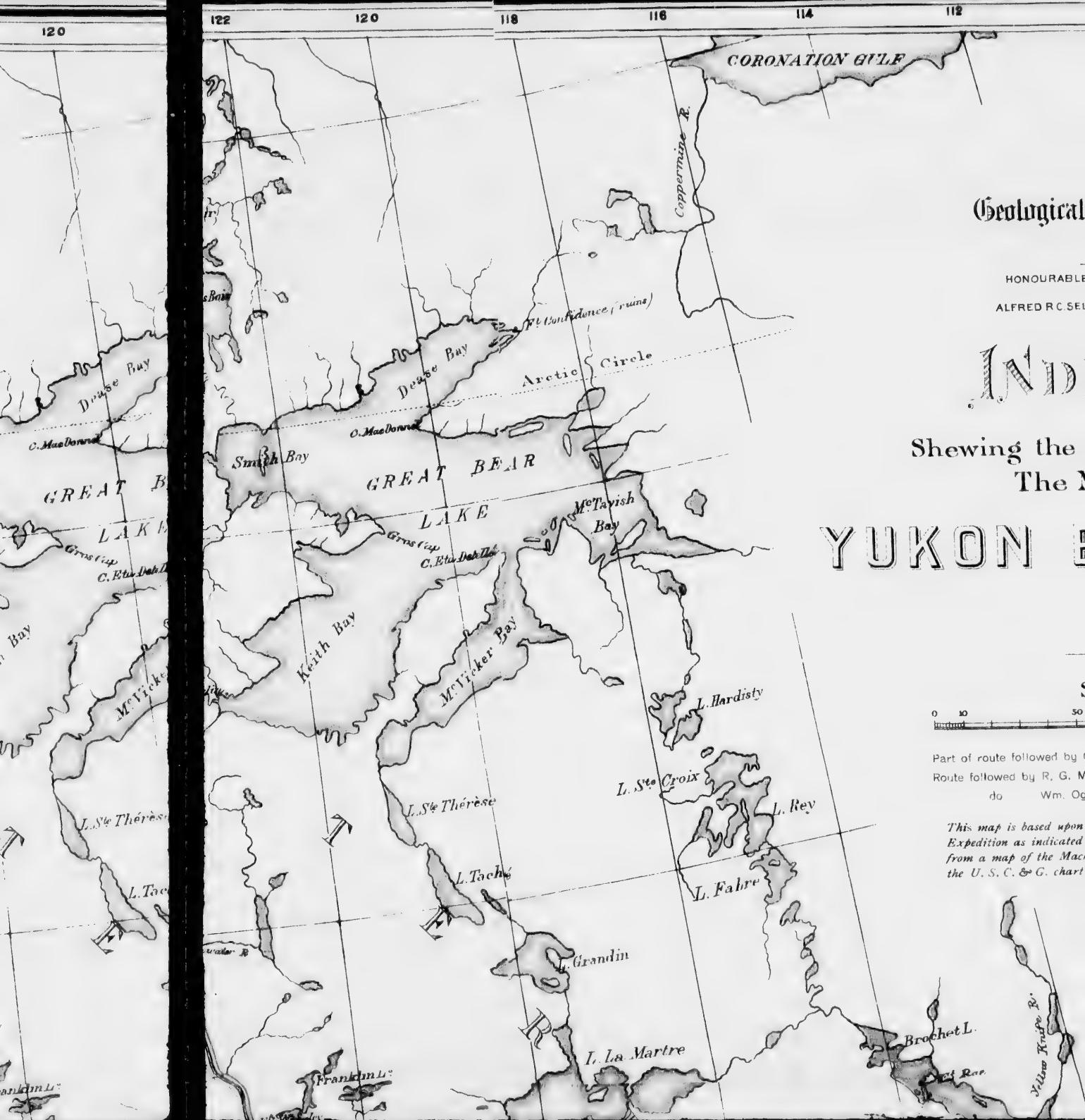
Cliff swallow (*Ptyonoprogne fuligula*) arrived.
Light showers.
Very light rain.
Ice piled up in high cliffs along shore.
A few drops of rain.
Anemone pinnatifida in bloom.
Fine weather.
Mosquitoes getting thick.
Three inches of snow.
Light rain.
Cloud disagreeable day.
Mosquitoes getting thick.
Vegetation scarcely begun.
Some flakes of snow.
Alders and willows in flower.











112 110 108 106

Bathurst
Inlet

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Geological Survey Department,
Canada.

HONOURABLE EDGAR DEWNEY, MINISTER

ALFRED R.C. SELWYN C.M.G., LL.D., F.R.S., &c. DIRECTOR.

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INDEX MAP

Shewing the ROUTES followed by
The Members of the

YUKON EXPEDITION

1887-1888.

Statute Miles.

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150

Part of route followed by G. M. Dawson, LL.D., F.G.S., &c., .

Route followed by R. G. McConnell, B.A.

do Wm. Ogilvie, D.L.S.

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Clinton Colden L.

62

McLeod's Bay

Christie's Bay

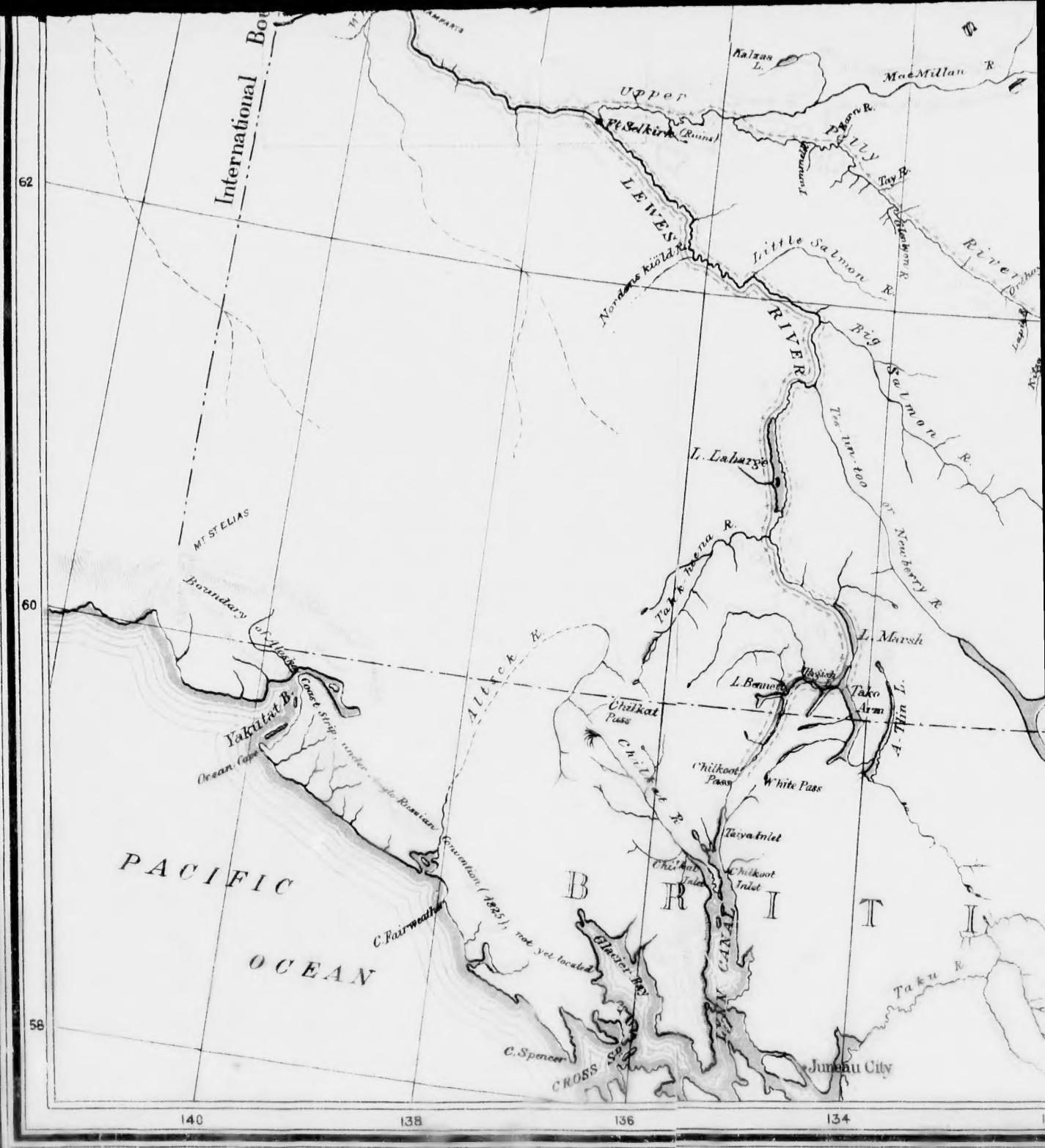
Reliance (ruins)

Chet L.

Yellowknife R.

at Rae

at Providence



Drawn and Autographed by C.O. Senecal, C.E. under the direction of S. Barlow, Chief Draughtsman.



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Longitude West 126° from Greenwich 124





The divisions marked "Sheet 1...9", are published on a scale of 8 miles to 1 inch, and accompany Part D, Annual Report, Vol. IV, 1890, by R. G. McConnell, B.A.